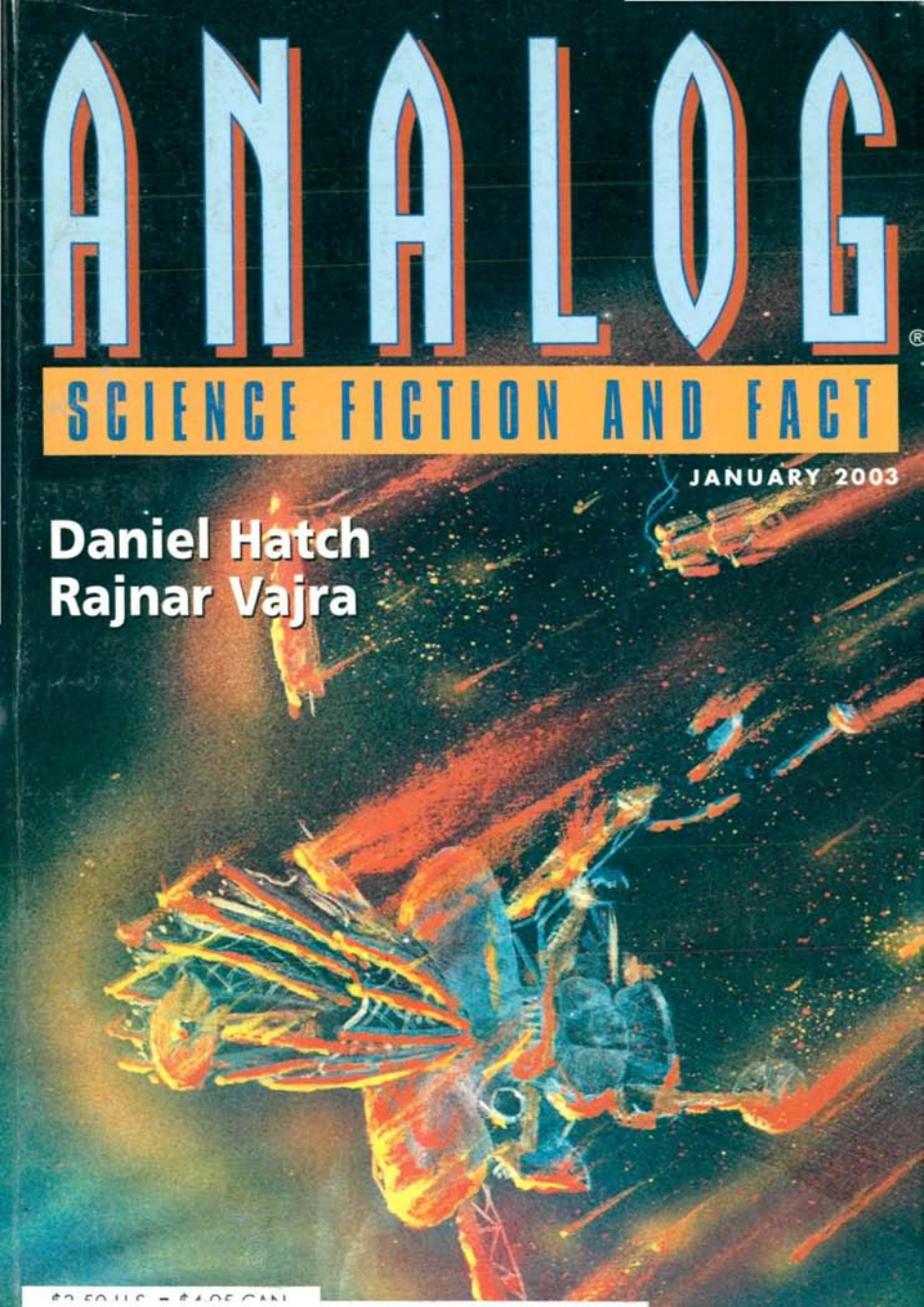
ANALOG

SCIENCE FICTION AND FACT

JANUARY 2003

Daniel Hatch
Rajnar Vajra



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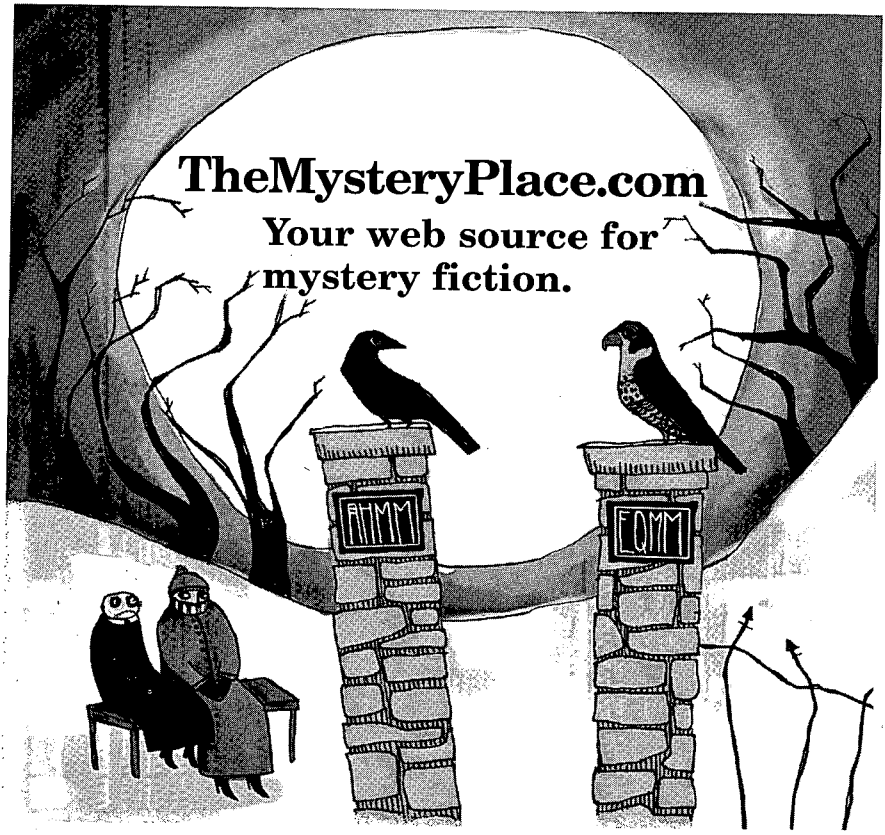

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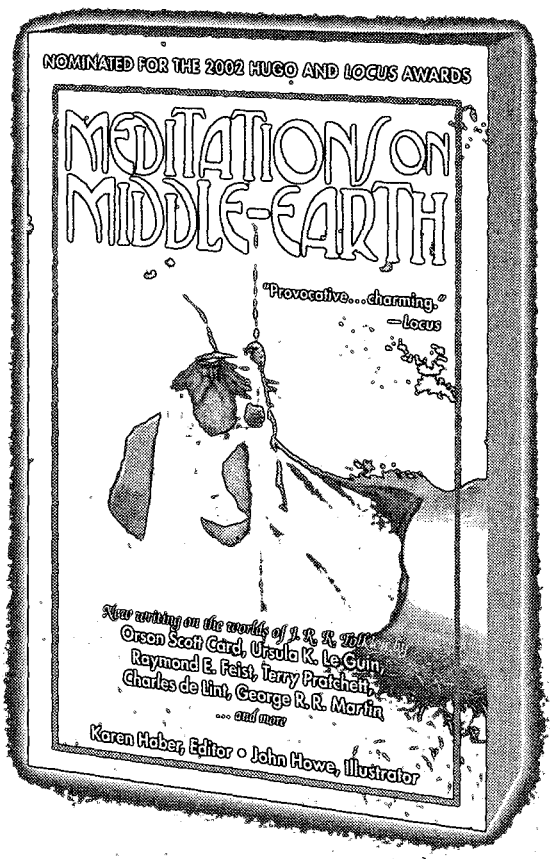
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EDITORIAL Stanley Schmidt

DRIVING FORCES

What makes a story "go"?

A story is not just a random sequence of events. What happens next must follow in some logical way from what has gone before and what is happening now. Things don't happen for no reason. The Newtonian idea that things tend to continue in their present state of motion (or nonmotion) unless acted on by some force applies just as well to *any* system. The forces that drive stories forward can come from external events, or from the nature of the characters themselves—or both.

Science fiction has often been criticized, especially in its early days, for an alleged tendency to neglect characterization and character development. There has been some basis in truth for this, though anyone who thinks it has always been true or always an intrinsic fault should read the chapters on character in James Gunn's book *The Science of Science-Fiction Writing* (Scarecrow Press, 2000). I will not attempt to repeat or summarize everything Gunn says, but I will observe that characterization *must* be central and well done in "mainstream" fiction because character is pretty much all that the mainstream author has to work with. In science fiction, novel ideas and backgrounds assume a much greater importance so that they can carry more of the burden of the story. In some cases (as Gunn points out in more depth), excessive attention to character may actually get in the way of things that are more important to a particular story.

Nevertheless, the characters are the people (or people-analogs) to whom the story happens, through whom the reader experiences it, and who (to varying degrees) *make* it happen. In recent years, science-fiction writers in general have become much more aware of this and have tended to pay more attention to making their characters believable and interesting and letting their actions grow out of their intrinsic characteristics—in other words, to letting what they do grow out of who they are. This is, at least up to a point, a welcome and admirable change. As Gunn (and likely others before him) put it, "Characters should always act for their reasons, not for the writer's reasons." But we have now come to a time in which many literary circles use "character-driven" as the highest term of praise for a story. This seems to me to go too far, getting uncomfortably close to an anthropocentric view of the Universe. Such a view is wrong, and has contributed to many of our past and present troubles.

We are often told that literature should (in some way) reflect the real Universe, but the Universe is not character-driven. Or rather, it is not *entirely* character-driven. If it were, we wouldn't have to worry about things like hurricanes, global warming, walking off the edges of cliffs, and so forth. People do choose actions for reasons deeply rooted in their characters, but they are also acted upon by external forces beyond their (or any other human's) control.

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And those things that happen *to* people, whether they want them to or not, can have profound effects on what their characters will be in the future—which, in turn, will (partially) determine still later actions.

Hence my discomfort with the currently fashionable idea that the best thing a story can be is "character-driven," as distinct from "idea-driven" or "plot-driven." Certainly character should be *one* of the driving forces, but an either-or argument is about on a par with nature vs. nurture. Certainly plenty of writers have neglected character, sometimes to the extent of conceiving a plot first, and then forcing their characters to do whatever they had to, to make the plot go that way. One of the most important lessons many fiction writers learn is that their original conception of the plot may be of value only to suggest characters who will then be strong enough to generate a quite different plot. A good way to see what happens next in a story is to look at every key juncture from the viewpoint of everybody affected by it, and let each one make the best possible move *as he or she conceives it*, which means it is determined not only by external circumstances or logic, but by the characters' own desires, fears, strengths, weaknesses, limitations, and foibles.

What the "Character-Driven-Über-Alles" theorists tend to forget is that, as important as character is as a driving force, those external circumstances can be important, too—and their effects must be dealt with as conscientiously and honestly as those of human character. Some things happen in a story not because of what characters want, but because of what natural law demands—and natural law is very exact and uncompromising in what it demands. This is true even in mainstream literature, though we tend to overlook that because so much of the natural background of mainstream fiction is given, familiar, and relatively unchanging.

For example, our Earth (on which all "mainstream" fiction is set) has an axial tilt of 23.5°. That fact underlies and pervades everything that happens to Earth-dwelling humans, in either reality or fiction. It is what causes our seasons and determines their duration and intensity, and those are among the most fundamental facts of human life. Change the tilt from 23.5° to zero or 55°, and you must rewrite virtually the entire body of human literature—not trivially, but radically. In one case, all references to seasons become meaningless; in the other, problems associated with seasonal change become far more drastic and require whole new cultural adaptations.

Hardly any mainstream writer or reader ever thinks about that because all of us have always lived with a 23.5° axial tilt. Its implications are deeply embedded in our gut-level assumptions about "how the world is." But worlds don't have to be that way, and in science fiction, where we open up our palette of

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possible settings to include all possible worlds, it becomes much more true that stories can't be entirely character-driven. Too often we're making radical changes in basic parameters that mainstream writers and readers take for granted, and once you specify new parameters, natural law dictates much of what must happen. The science-fiction author who wants to be taken seriously must work out as much as he can of those consequences, and take seriously the fact that they dictate fundamental constraints within which his characters can and must act. How humans respond to things that happen within that altered framework should still be dictated by who they are and what they want (within the limits of what natural law lets them do!), but working out what happens physically demands just as careful attention as working out how the characters behave.

If I may use an example from one of my own stories (SPOILER WARNING for anyone who hasn't read it and might be contemplating doing so!), in *Lifeboat Earth* our planet is (for reasons I won't divulge here) used in its entirety as a "spaceship" for a *very* long voyage. Doing so naturally requires the application of some fundamentally new science that we in 2003 haven't yet discovered (and likely never will). But if you grant that one assumption, a great deal of what must happen is dictated by the assumed properties of the new drive system—and the whole body of science that we do already know.

Much of the Earth's own mass is consumed as "fuel" for the journey, which implies that its gravity gradually decreases. Concurrently, its acceleration along its axis feels to its occupants like an extra gravitational field added vectorially to the true gravity. What this means, from the viewpoint of somebody living on the Earth, is that every point on the surface appears to tilt, and all the water and air redistributes itself by flowing toward the South Pole. It is possible to calculate such things as how much the apparent gravity and tilt are at any point on the surface at any time during the trip, where in the sky the Sun appears and how bright it looks, etc., etc.

And since it is possible to calculate such things (and some readers always will!), I as author was obligated to do so. The *story* was *not* primarily about the physical changes, but about how people's (and other animals') lives were

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changed by them, and how they adapted to extreme hardships and loss in pursuit of eventual survival. How the story played out was very much determined by what kind of people Henry Clark and Sandy Turabian and many others were. But it was no less determined by the physics that dictated the kind of changing world with which they had to deal. If I had approached it as a purely character-driven story, I would presumably have given no detailed thought to those matters—and I might have wound up with a story that looked like Literature to purely literary folk, but like blatant nonsense to anyone with any understanding of how the physical Universe works.

To argue about whether science fiction should be "idea-driven" or "character-driven" makes about as much sense as arguing over whether nature or nurture determines who we are. It takes only a modicum of observation and thought to realize that *both* nature and nurture, acting with and against each other, shape people; and that both people's character and the laws of the world they inhabit determine what can and must happen to them—in either reality or fiction.

Or, to put it in a slightly different way, I can accept the idea that stories should be completely character-driven—as long as you recognize that the Universe itself is always a major character. ■

I think there is only one quality worse than hardness of heart, and that is softness of head.

—Theodore Roosevelt

There is no conceivable human action which custom has not at one time justified and at another condemned.

—Joseph Wood Krutch

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SEED OF DESTINY

Daniel Hatch

Illustration by Nicola Cuti

It was a job such as no geneticist had faced before—but then, it was a *world* such as no geneticist had faced before.

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God, the old myths claimed, escaped the chamalian Eden after being attacked and raped by its wild creatures. The Seed of God gave wisdom to every wild creature of the world, but with it came a curse—in their wisdom they could imagine a moral purity that they could never attain.

— Mark Paradis, *Text on the Moral Dilemma of Wisdom*

The sound of firecrackers echoed in the courtyard of the Hall of the Seedkeepers. The dissenters meant them to mimic the crackle of gunfire and keep everyone inside on edge. After four nights, nearly every creature inside the hall, wise and wild, was about as nervous as chamalians get—and that was nervous indeed.

But it wasn't having its intended effect on Jerome Sullivan, who continued to play solitaire on his mindpad.

He moved the cards quickly and unconsciously, his mind lost in the reverie of discovery. The game was a version of gaps, modified to add knaves, bishops, and fools to the face cards to make sixteen cards in each suit, sixty-four to the deck. Just the right number to simulate the shuffling of chamalian genes.

"All he ever does is play solitaire." That's what Alyska Spenskaya had said back at the compound in the jungle.

She wanted him to split genes, cook up oligonucleotides, and crack codes. Instead, he spent his time slapping virtual cards around on a virtual green felt tablecloth. It drove her up the wall. It bothered her so much that she finally sent him off to the chamalian city of Suridash as punishment.

He could either do something useful in the Hall of the Seedkeepers or prove he was too lazy or incompetent to remain on Chamal and be sent back to Earth.

But he had confounded her. Sent off to work by himself, he had accomplished the impossible: He had solved the ultimate puzzle of Chamal. He had achieved the elusive goal that human researchers had been seeking for years and alien researchers for centuries. Him, Jerome Sullivan, the lazy, absent-minded, solitaire-playing goof-off.

He hadn't told anyone yet; not Alyska Spenskaya, not his chamalian Seedkeeper assistant, Yulish. He had not spoken his understanding aloud or written it down. Apart from fragmentary notes and diagrams on the smartboard, it existed only as an apparition in his mind, a piece of knowledge not quite yet born.

While his hands twitched and the cards moved, he reveled in his private comprehension of nature. He felt disembodied. He looked down on himself in the middle of this alien city, alone and surrounded by stone, desert, jungle, and sea, a single brain containing the secret of a planetful of life.

He savored the moment. It would pass all too quickly. Yulish would return shortly, and he couldn't resist sharing the knowledge with her. And like a network virus, once it was out, it couldn't be called back. He would dictate his notes into the mindpad, edit them into a decent text, and transmit them to Alyska at the compound in Paradise Lost.

He reached a dead end in the solitaire game and pushed the mindpad away. The mixed clutter of alien and human science was piled high around him. Scrolls and ten-centimeter-thick leather-bound volumes teetered in tall piles next to his chrome-plated gene machine and his white ceramic AI. Tapestries depicting scenes from the patriarch Jobe's experiments as a frog farmer, which laid the foundation of the chamalian study of genetics, hung on the walls. A black smartboard covered with Jerome's charts and diagrams leaned against one.

He jumped up and danced across the room. It was an awkward dance, but he was an awkward young man. Jerome had a number of problems. He was big and ungainly. His thick lips often had a

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hard time working their way around words. He kept his face clean-shaven, but he needed a haircut. He had a month-old sore on one lip from the dry desert air and a rash of unknown origin on his wrist. To look at him, you would hardly believe he was one of the brilliant young scientists in his field. But in the privacy of this chamber, enthralled by this triumphant moment of revelation, he put all that aside and he danced.

He rushed to the balcony and looked down into the crowded courtyard below. The dissenters had just set off more firecrackers, but they were starting to settle down, sitting around small metal barrels full of burning wood.

Jerome could barely see their faces from here. He could pretend they were all the same, all cast from one mold, but that was a fiction of distance. He knew the truth: that each face was different in ways that betrayed the peculiar genealogy of Chamal. There were some with snouts, some without. Some with big ears, some with small. Some on four legs, some on two. So many of the different subspecies of the planet were represented down below—desert cats, steppe hounds, jungle apes, mountain bears, and more. And all bore the marks of wisdom: the ability to speak and to make and use tools. On Chamal, intelligence was not the exclusive property of a single dominant species, but came in countless forms. Every breed had its wise members and its wild.

Three skyrockets whooshed up from below and exploded overhead with three loud booms. The Sun was just beginning to touch the horizon. Jerome wondered if the rockets were some kind of signal, or just a marking of the day's end. Or both.

He looked out at the city, spread below him in the rapidly fading light at the end of the short chamalian day. Suridash was the creation of refugees. Clans and tribes cast out of the green lands to both the north and south had made new homes here among the other outcasts of a chaotic world—surrounding their homes with high walls to keep their new neighbors out and their own kin in. The great city walls blended into the smaller private walls that set off the enclaves of the largest tribes. The spiraling towers of the Chokai, trimmed with iron filigree, rose in the east. The teetering chimneys on the workhouses and foundries of the Red Monkey enclave spilled brown smoke into the northern sky. The ruins of the Ravina enclave lay dark and silent to the west.

The dry desert air made them seem almost within arm's reach, miniatures populated with tiny alien creatures. More enclaves lay to the west and south behind him, and in the spaces between were complicated mazes of ramparts marking the boundaries of minor clans, tribes, breeds, and subspecies. Walls within walls within walls.

But the rough anarchy of the chamalian city was only a surface effect. While the casual observer might see an impossible collection of freaks and sports, underneath it all was an order more profound than anything Jerome had ever encountered—a system, a key to the lunacy. Keys within keys within keys.

And he was in a position to turn the key and unlock the spirit of this lunatic race.

"I love you guys!" Jerome shouted, his voice lost in the tumult below. "You thought your secret would stay hidden forever, but you were wrong! I figured you all out!"

He felt the wind of destiny lift him to new heights and he drummed his hands on the stone balustrade until they hurt.

"I am a goddamn genius!" he proclaimed to the empty air, daring to tempt fate with a boast that he almost believed.

Then the door to the chamber swung open behind him and slammed against the wall with a bang.

Jerome turned suddenly, expecting to

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see Yulish, back from her evening meal, though he couldn't understand why she would be so reckless with the woodwork.

Instead, he found himself facing more than a dozen chamalians wearing the green robes of dissenters, but with dark scarves across their faces. They were armed with ugly black weapons, and beneath the robes and masks Jerome could see bright crimson fur.

He drew a short gasp as he realized something was terribly wrong. These weren't dissenting Seedkeepers arguing a point of doctrine. They were red monkeys—and they didn't belong here.

And in one dread moment, Jerome realized how easily his tremendous discovery could be lost before the world even knew he had discovered it.

The monkeys scrambled into the room. None of them was more than a meter tall. They had long arms and short legs and small round heads with wide mouths, and they were all over the place all at once, jumping onto table tops, poking into lockers, peeking under furniture. And yet at any one time there were never fewer than four of them pointing their weapons at Jerome. Never the same four, but always four.

The shortest of them carried no weapon of his own and his scarf hung loosely around his neck instead of covering his face. He hopped up on to Jerome's desk and began examining the equipment. He put a large hand on the top of the AI, taking the measure of the ceramic hull, then picked it up.

"Hey, I wouldn't do that if I were you," Jerome said.

The red monkey looked at him and shook the AI. A chime rang in Jerome's right ear and the voice of the Professor announced: "System fault—switching to safe mode."

Jerome mustered his nerve and tried to remember what Alyska Spenskaya and her husband had told him about dealing with chamalians. Be direct and forward, they'd said. He had an advantage. The chamalians thought of humans as angels, messengers from god. Some even took the idea literally. At first he thought that was a good thing. It was not. Chamalians were not on good terms with their god. Angels were not welcome on their world, but feared and distrusted.

With all that in mind, Jerome walked to the center of the room and said: "I'll call you 'Shorty,' because it's easy to remember. I'm afraid we can't communicate now that you've knocked the AI offline. He's the interpreter."

Shorty looked up and down Jerome's large frame, rubbed the fabric of the terrestrial clothing with his alien fingers, and poked at the human's knees and knuckles. Then he jumped from the desk to the workbench and up onto a shelf so he could look down on everyone.

"Nikla!" he announced. The squad of red monkeys stiffened and drew back.

"Hik, hik, hee-hay-hee-ah-too," he ordered, barking out the short sharp syllables.

Half the monkeys lowered their weapons, slung them across their backs, and produced empty packs. Shorty led them around Jerome's room, touching the items of value, each time ordering: "Hik."

Everything he touched went into the packs. They grabbed the books and scrolls and charts on the tables. They took the AI. Jerome began to protest when Shorty touched the mindpad, but swallowed his words when six more monkeys pointed their weapons at him at once.

Shorty barked some more commands and the squad wrapped the gene machine in cargo netting and slung it from a pole resting on the shoulders of two monkeys. Another pair was drafted into taking down the smartboard and carrying it with them.

When the room was picked clean of everything useful, Shorty returned to

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Jerome. When the red monkey reached up to touch him, Jerome realized with a start what was happening: They were kidnapping him.

He put up his hand and stepped back. He touched his personal pack, the portachef, and a foul-weather poncho and said: "Hik, hik, hik. If you're taking me with you, I'll need to wash and eat from time to time."

Shorty clapped his hands and the squad members added his items to their booty. Then the red monkey leader bared a mouthful of narrow, sharp teeth, and Jerome wondered if the alien smile meant the same thing to chamalians as humans.

The monkey leader barked out another set of commands and suddenly the monkeys were all over Jerome, holding him tightly by the arms and legs. One of them pulled his left arm down to where Shorty could reach it. Shorty grabbed Jerome's hand, turning it one way, then the other, twisting it painfully in directions it wasn't meant to go.

Jerome yelped, but the monkeys only held him more tightly. Shorty reached over his shoulder to the pack on his back and produced a small knife with a bone handle.

"Hik," he said, pointing to Jerome's hand. One of the monkeys held it tightly with small, brown fingers. Shorty reached out, took Jerome's little finger in one hand, and put the knife at its base.

"Hey, quit fooling around!" Jerome yelled. He struggled violently, but the monkeys held him fast.

Shorty was quick and adept. Jerome felt the blade cut him, then Shorty stepped back. The red monkey pulled the scarf from his neck, cut a piece off one end and wrapped it around the finger, then tossed the rest of the scarf at Jerome. He put the finger in a pocket on his vest and fastened the pocket tightly.

Jerome felt the monkeys relax their grip on him as the shock set in. He looked at his hand, saw the blood flowing away where his finger had been, and felt faint. One of the monkeys handed him Shorty's scarf. He wrapped it around his hand as tightly as he could. Where was his pack? That would have the first-aid kit. He looked around and saw Shorty and another monkey going through it, pulling everything out one item at a time and examining it carefully. He moaned loudly and the monkeys grabbed him again. He relaxed, and they released him, stepping back and bringing their weapons to bear on him again.

"Hey Shorty, what did you do that for? It hurts like hell and you've got my first-aid kit."

Shorty looked up, aware, it seemed, that Jerome was addressing him, but making no response. Jerome was pleased to see the monkeys return everything to his pack, but no one looked ready to give it to him.

"This really hurts, and it's going to get infected," Jerome said. "It would be nice if you could give me the first-aid kit."

Shorty stared at him blankly.

"Professor, are you there?" he said, trying to get a response from his AI. "Could you try to get a message through to this short little bastard?"

There was no answer.

Shorty looked around the room once more, then gave a final command. Someone poked Jerome in the side and they hustled out into the hallway. Jerome hurried to keep up with his guard and winced as he swung his left arm at the fast pace.

The squad moved like a many-legged beast, each foot reaching out to a new hold, some for balance, some for progress. Outrunners posted themselves at the south end of the hallway, while the rest went north. The lead team at the north intersection held them there while the rest of the group caught up.

Shorty was the last to join them. He

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came scurrying up the corridor after everyone else was there, then he turned and looked back the way he had come. He waited, they all waited, no one making a sound. Then—

BOOM-BOOM!

The shock wave hit Jerome in the face and the chest. Smoke rolled down the hallway and surrounded them, smelly and hot on Jerome's face and hands and throat.

"Was that necessary?" Jerome asked Shorty. Shorty continued to ignore him as they rushed off to the east.

As he hustled along the corridor, Jerome tried to ignore the pain in his hand. He had more serious concerns. This was happening at the worst possible moment. If the red monkeys killed him, or even if they simply held him prisoner, his discovery would remain unknown to the rest of the world. It could be lost forever. And no one would ever know that he, Jerome Sullivan, had been the first to see it.

Yulish hurried up the wide stone staircase with the guilty knowledge that she was late returning from dinner. She didn't even pause to step on the mid-stair twice to ward off bad *cha*.

Her wiser voice told her that such superstitions were irrational and unscientific and that she should not cling to them so tightly. The same wiser voice would not normally allow her to leave the angel Jerome Sullivan alone for this long, for fear that he would jeopardize his own safety.

Yulish had grown up thinking of the angels as deadly creatures who flew across the sky, ready to destroy the world if it displeased them. But the angels turned out to be much less frightening in person than in the imagination. Jerome might come from a race where the inheritance of wisdom held a purity lacking on her world, but he was truly hapless when it came to common things. He was lucky he had a machine to make him food or he would have starved to death from forgetting to eat. His wisdom too often took possession of itself and left him staring blankly at a screen filled with a flickering array of rectangular symbols that she could not decipher.

She had tarried too long in the communications center. She wanted to listen to the night broadcast from Mark Paradis, the angel on the radio. This week, he and his students were discussing one of their wise patriarchs—an angel named Spinoza. He was the first of the angels to argue that power should protect freedom of thought instead of suppressing it. She enjoyed hearing the angels talk to each other about such dangerous and radical ideas.

Yulish had become the first female to wear the robes of a Seedkeeper. She was not sure if it was in honor of that distinction or as punishment for it that she was assigned to be the attendant of the angel Jerome Sullivan. Of the sixteen angels who lived and worked in the Hall of the Seedkeepers, he was the youngest and most difficult.

Even now, as she hurried up the final set of stairs to his chambers, she wished she had been given some other duty. Her lessons in the mysteries of the Seed of God were now complete. She was ready to take her place in the study and analysis of its ebb and flow. But instead, she had to teach this strange angel things every pup in Suridash knew. She wondered if she had offended some long-buried ancestor and now suffered under a curse.

In her haste, she almost stumbled on the top step before the next landing. As she recovered her balance, a tremendous *BOOM-BOOM* slammed full against her body. She drew a sudden breath in panic and her hearts squeezed hard within her. Then she was brought up short by the appearance of an armed squad of red monkeys with Jerome Sullivan in their midst.

A half hour later, after a rushed jour-

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ney through the twisting streets of Suridash, the party arrived at the red monkey enclave. Jerome was amazed by the jumble of architecture—massive stone buildings, delicate brick structures, huts of mud and wood, all jammed together without plan or organization.

The red monkeys took Jerome and Yulish to a building of ochre bricks and led them up several flights of narrow stairs. They filed down a long hallway with a low ceiling that forced Jerome to crouch slightly as he walked. The lighting consisted of a series of incandescent bulbs set in recessed grilles in the ceiling—primitive technology, but effective.

At the end of the hallway was a large room full of workbenches and cabinets, all empty. When the entire squad had entered the room, Shorty barked a long string of commands. The red monkeys emptied their packs of the items they had stolen from Jerome's room, lining them up along an empty bench. They leaned the smartboard against one wall.

Jerome's eyes found his pack and his heart leapt with joy and sank with sadness. If he could only get his hands on his first-aid kit, his pain would end, but it might as well be back in the Hall of the Seedkeepers.

Squad members produced long chains from the back of the room. The links were solid pieces of black metal with pairs of swivel joints, a labor-intensive piece of work. One end of each chain was fastened to an anchor in the wall. At the other end were cuffs, which the monkeys fitted around his ankle and Yulish's. Jerome felt a chill when he saw that a line of anchors ran along all four walls.

When Shorty was satisfied that they were secure, he ordered the squad to form up. Then they scrambled out of the room, leaving Shorty and a single guard behind. Shorty looked them over one last time, spoke briefly to the guard, then left.

Jerome felt cold and alone in a way that he had never known before. The benches with his gear were out of reach. The AI was still offline. His hand throbbed and ached, and the blood had thoroughly soaked the makeshift bandage. He took it off slowly.

Yulish came over to him and took the bloody cloth. She found a basin with running water in one corner and rinsed it out. While she was at the basin, Jerome inspected the wound. The cut was smooth. Blood seeped from its surface. Looking at it made him feel faint, but he couldn't turn his eyes away.

Yulish returned with the bandage and looked at his hand. She led him back to the basin and washed it off.

"I do okay for you," she said.

"You do okay," Jerome replied.

The guard found them blankets, but the only place for them to rest was the rough wooden floor. Jerome realized that they would be spending the night there, and that realization brought on a sudden wave of despair. He hadn't felt this bad for years. Twenty years, more or less.

Jerome's life had never been easy. He was dyslexic. The teachers had discovered it when he started school, so his childhood had been full of extra lessons and drills and practices to overcome his disability. They were alternately boring and exhausting and they were designed to retrain a brain that was wired differently.

Their effect, however, was to set Jerome apart from his schoolmates and turn him into an outcast. Despite his disability, Jerome was possessed of a quick and agile mind. While he had trouble reading, he had no trouble reasoning, and once he had absorbed the material he read, he was as capable as anyone else. More capable. He raced ahead of the others, slowed only by his troubles reading and writing.

And that separated him even further from his mates. The result was that he kept his knowledge to himself, kept to himself generally, and wondered

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throughout his adolescence why he was cursed with such a fate—to never be like the other children around him, to never be a part of their lives and their world. So isolation like this was not something entirely new to Jerome. In some ways, only the faces and names and planet had changed.

College and grad school had changed that somewhat. There he was recognized for his abilities and his talents. He still kept to himself and devoted most of his time to his studies, which gave him an added advantage over his classmates, but by then he didn't mind the isolation and even came to treasure it.

It was only when he ended up at the compound with Alyska Spenskaya that the old problems returned. She expected him to be part of her team, but he was not a team player and he never would be. And this was where it had gotten him—chained to the wall of a workshop on a world of aliens that only he truly understood.

But they had left him with his equipment, his notes, the charts he had made, the AI (which would reset itself soon enough), and the mindpad. All his work was still intact.

Even if he was cut off from contact with the other humans on the planet, he would find a way to complete his research and write it up. That way, he decided with grim resignation, if anything happened to him, he would still be entitled to the posthumous credit for the original insight that belonged to him and him alone.

Yulish tried to calm herself enough to sleep, but it was hard.

She felt guilty over what had happened. Had she brought bad cha on Jerome Sullivan and herself by ignoring the rituals, irrational and superstitious though they were? She had thrown away her charm bag, stopped wearing a scarf during the full of the Great Moon, and ate gray frog soup whenever she pleased. Was she being punished for her pride?

And she was afraid. Not just for herself, but for all Chamal. And not over superstitious nonsense.

The red monkeys had kidnapped an angel. Did they really know what they were doing? Did they truly understand the consequences of such a crime? What if they killed him? What if he hurt himself or took ill or simply went mad? What would the angels do when they found out? How long would it be before they found out?

The questions danced around and around, making her head spin. Even her wiser voice could not provide answers, only greater and more disturbing questions. When she finally surrendered to the night, it was with a struggle—one that interrupted her slumber repeatedly.

The next day got off to a better start. The red monkeys brought them bread and sweet jam for breakfast. And the Wise Teacher of the Wise had returned to life, so Jerome could once again carry on a useful conversation with Yulish. But his first questions brought back her fears.

"What can you tell me about the red monkeys?" he asked.

"What can I tell you? Do you wish to hear the stories that frighten growing pups? Or the history of the Great Rift Valley? Or should I explain the politics of Suridash?"

"All of the above," Jerome said. "Start with the frightening stories."

Yulish was hesitant, but unable to resist the angel's desire. She snatched up the last piece of bread and began.

"In the wide Rift Valley, full of wild streams and lazy rivers, of smoking mountains and hot springs, live countless breeds of chamalian," she said, the singsong rhythm of her voice trembling in her own ears. "But one breed is special. It sleeps in all the others, dreaming for many years. And then, every four hundred years, the Red Monkey awakes.

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"They are born everywhere at once, born hungry, born ambitious, born wiser than any of the wise. As the pups grow into halflings, more pups appear. By the time the first of them is grown, they rule the valley, and still more come. As the younglings come of age, they enslave all the other breeds and turn them to their purpose, and still more come. Their wisdom spawns new inventions, new devices, new wonders. And then one day, they turn on one another, with vengeance in their hearts, old waging war against young, young fighting back with terrible power, and the blood of the Red Monkey stains the great river. And eventually none are left and the Red Monkey returns to the land of dreams."

"That's scary enough," he said, his eyes wide. "What about the history of the Rift Valley?"

"It is the history of the Red Monkey. Back in the earliest times that are written of, they formed the first empires and tamed the flowing waters with dams and canals and aqueducts. And when their time ended, the dams crumbled, the canals filled, and the aqueducts fell. Each time they return, they rebuild them—and go on to do more. Mills, factories, laboratories, libraries. They are the inventors of machines, of bronze and steel, of gunpowder and steam, of rockets and electricity. And each time they pass on, many of their inventions are lost until some other breed in some other place finds them anew. They are the story of our race—greatness and misery combined in one seed."

"I see," Jerome said. He contemplated her words silently for a time, then asked: "And what about city politics?"

"The last Red Monkey awoke more than two hundred years ago, following the path of its predecessors, waging a great war that tore the Rift Valley with fire and blood. When it ended, all the red monkeys were dead—but for a single clan that fled for its life to this desert. Suridash was their final refuge, their sanctuary. Travel farther in any direction and you draw closer to other great civilizations. Even here, their breed would have disappeared in time. That's the nature of our seed. But the Seedkeepers of Suridash held the knowledge necessary to prevent that from happening. By showing them how to breed the stepling and the halfling, and track its seed and calculate its paths, they were able to produce new red monkeys each generation, just enough to maintain their clan. In return, they shared the science of their forefathers with the Seedkeepers—and the city. It is a balance that has worked well since the time of Jobe."

"I know about Jobe," Jerome said. "He was the patriarch who built the Hall of the Seedkeepers. He's a big hit on the cablenet back home."

"Jobe was the one who brought us our first understanding of the Seed of God," Yulish said. "He built the Great Library, founded his tribe, and sent pilgrims to follow his Way."

"And he circumnavigated the planet."

"Yes," Yulish said. "It was how he became so wise."

"Sounds like he might almost have been a match for the red monkeys."

"He was equal to the task. He brokered the agreement that let them stay here in Suridash, safe from their enemies in the Rift Valley."

"Good for him," Jerome said. "If you can negotiate with them, that means there might be hope for us."

"You may think so," Yulish said. "I am too humble to suggest it."

"Which leaves me with one very important question," he said. "What do the red monkeys want?"

"What do the red monkeys want?" Yulish hissed. "That's a fool's question. They want what they always have wanted—they want power. They want to control everything within their reach, wise and wild, live and not-live. They

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want the Rift Valley. And when they have the Rift Valley, they will want Chamal. And if they have Chamal, there will be no end to their wanting."

Jerome was set back by the sudden intensity of Yulish's tirade. The words from the Professor lagged behind hers, but their strength and passion carried over. He wondered what it must be like to have creatures like the red monkeys living in your city, biding their time, waiting for their breed to return in strength.

"I guess they're not very good neighbors," Jerome said.

"They care about nothing but themselves. They hold uncounted slaves, chained to the machinery of their factories. When they held power over the Rift Valley, they turned every breed, every clan, every living creature, to their purpose, all working to serve the Red Monkey. Every other creature is a means to an end. They care nothing of wisdom for its own sake. They will squeeze every drop of usefulness from you. They will exploit your every ability, every talent, every gift, for their own needs and desires."

"And in that, how are they different from any other creature on Chamal?"

"They are much better at it than the rest of us," Yulish said.

That final revelation was the last bit of preparation Jerome had before his first audience with a red monkey leader.

The doors swung open and Shorty entered, followed by his squad of gun-toting clansmen. They had stripped off their disguises and were decked out in orange and blue uniforms.

Behind them strutted an older clansman; the fur on his temples and his sidewhiskers had turned white and his skin was an almost transparent pink. That put his age at the upper end of the chamalian lifespan, maybe thirty-five years in human measurement, a limit that had surprised Jerome by its brevity.

They were not really monkeys, of course. Nor were Chamal's desert hounds hounds nor the tree cats cats nor the green apes apes. Those were compromises of terminology, artifacts of the AI that interpreted the chamalian dialects into English. There were resemblances that prompted the poetic labels. Shorty and his breed resembled primates, and their large heads, long jaws, and quick manner invited the comparison to terrestrial monkeys. Yulish's cleft lip, her floppy ears, and her square teeth all reminded Jerome of some oversized hare with an extended vocabulary. Desert hounds were carnivores with long snouts and long eyeteeth, while tree cats were carnivores with small snouts and sharp claws and fur that came in a hundred shades of green. It wasn't scientific, but it served its purpose. Jerome reminded himself of this as the two red monkeys conversed, to help him avoid falling into a trap of anthropomorphic projection. These were dangerous creatures, willful and cunning. They were not cute specimens from a zoo gone wild.

The elder monkey clambered up a wooden lattice next to the door and perched at the top. From there he could look down on Shorty's militia, but he was still only eye-to-eye with Jerome.

"I am Kwi-lo-rak Do-sha-man-kay," he announced. "My grand-nephew claims you as a prize of war. You are the first angel I have ever seen at such a close distance. I didn't realize your breed was so large."

"(He speaks the common dialect of the city,)" the Professor interjected.

"We come in many sizes," Jerome said. "I'm kind of tall for my race. And heavy. But it's all lean. No fat. I'm just big-boned."

"Big-boned?" Kwi asked, tilting his head, then shaking his hands. "No matter. I came to tell you that you should not expect rescue. My grandnephew secured a sample of your tissues. We have paid Seedkeepers to offer it as proof—we have prepared it properly—that you were killed in the explosion. The other

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angels will believe you are dead and will not look for you. You are our property now. You must obey our will."

Jerome sighed. He had been dreading this moment for as long as he had been expecting it. He had given his response some thought. Now it was time to see if it would work.

"That's a good opening position for negotiations," Jerome said. "But you've never bargained with an angel before, have you?"

It was part bluff, part nervous rambling, but Jerome was accustomed to bluffing. It was how he had treated his schoolmates and his professors. It was his way of keeping them at arm's length and then manipulating them there. It was what had brought him to Chamal in the first place. And what would the red monkeys do if they didn't like it—cut off another finger?

"Bargaining? Over what? We control your life. We can end it in an instant."

"And so can I," Jerome replied. "If I do not eat, if I do not drink, if I cut my wrists and bleed to death, I will escape your power and you cannot bring me back. I am no use to you dead. If it's wisdom you want, you have found yourself a platinum mine. But if you don't recognize that we're both in this together, then you might as well kill me now for all the value you're likely to get from it."

Kwi tilted his head again. He spoke to Shorty—according to the Professor, in another dialect that wasn't in the AI's library—then he bared his teeth and chittered softly. The Professor said that they were a smile and laughter, though Jerome wasn't confident about it.

"You're right," Kwi said. "I've never bargained with an angel before. It is an interesting experience."

"I'll bet it is," Jerome said. "First, I'll tell you what I need, and then you tell me what you need."

By the time they were done, Jerome had Shorty's squad setting up the workshop for him, with the gene machine, the AI, and his mindpad covering a small table to the side, the smartboard hanging from the wall, the portachef rigged next to the water basin, and his pack—with the first aid kit—in his hands.

And in return, all they wanted was for him to continue his work—but with a special focus for them.

Their objective was ambitious, to say the least. They wanted him to unlock their seed and enable them to breed true. They wanted him to create a generation large enough to fulfill their destiny. They wanted him to awake the Red Monkey two centuries ahead of schedule.

And he agreed to do it all.

For years, Jerome had followed Spenskaya's cablenet reports on chamalian genetics and her husband's analysis of their politics and history. His fascination with this world was indefatigable, even in captivity.

It wasn't just that Chamal's unusual genetics allowed tremendous diversity. It was the terrible power with which it demanded diversity.

Where terrestrial genes had evolved to preserve survival traits in individual species, chamalian genes had evolved to preserve the raw traits—and to distribute them as widely as possible. The chamalian gene-strain abhorred hierarchy and centralization. It was democratic and anarchic right down to its biochemical action.

Intelligent chamalians could try to fight against this centrifugal force—they could try to create their own hierarchies and centralizations—but they were doomed to failure.

Throughout chamalian history, breeds had tried to preserve their seed, but wisdom was the quickest of traits to flee into the wild. After a few generations, intelligent tree cats, for example, would grow fewer in number as the traits for intelligence dissipated back into the gene pool, carried away by steplings and puplings that never ma-

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tured. Clans could counter this tendency by recovering their wise offspring among the wild, but wisdom never tied itself to any given phenotype for long. Some tried inbreeding, which worked for a couple of generations. But that only hastened the end, burying the traits of wisdom more deeply than ever.

Against this landscape, history proceeded.

Despite the powerful forces working against them, civilizations arose. And fell. And rose again. And fell again. On and on, as the vicious cycle repeated itself, the wise creatures of Chamal accumulated inventions and languages and philosophies and all the outward trappings of an advanced intelligent race.

Today, the trading states surrounding the highland sea of Meshkar were large enough to sustain teeming populations of cooperating chamalians, despite constantly shifting struggles for power over the trade agreements. The winged masters of the desert basin of Arkaria seemed to reconstitute their reign after each migratory season—but always with different individuals in positions of power. The civilization of the Rift Valley had continued on after the fall of the last red monkey empire with a pale imitation of its glory—until the arrival of the first human starship ended the rule of the less capable blue monkeys. The spiritual mentors in the Kwikorak mountain range shunned purely political power—and forged a technological empire in its place. Vegetarians had ruled in Rikabar for nearly a century, and the great predatory cats of Birhat had been masters of the steppes for many more—and only geography kept them from annihilating one another in a genocidal holocaust.

But dynasties could not long endure. Primacy was not the lot of any city or state for more than a few generations. The curse of the Red Monkey visited itself on every regime.

Suridash was an exception, unique in the persistence of its stability. The city maintained itself by encouraging the mixing of breeds. No single phenotype could claim power. Rats could not lord it over rabbits, dogs had no dominion over cats, bears could not rule raccoons. All were equal.

And that was due to the patriarch, Jobe. On his walk around the world, Jobe had learned many things. He had compiled the first statistical studies of chamalian genes, gleaned from the frog farmers of the equatorial rainforest. In the years since his return to Suridash, the Seedkeepers had expanded on that knowledge, cultivating the Seed of God, the traits of wisdom, by carefully recording and collecting and conserving the steplings and puplings and halflings that carried those traits locked in the hidden caches of their genes.

It was a purely statistical study, but Jerome was a statistical geneticist. He was impressed by the thoroughness of the Seedkeeper records and by the powerful database they offered. Like Mendel on Earth, Jobe had deduced the ability of genes to carry traits without ever seeing a gene or a chromosome or ever imagining a molecule of such complex beauty as DNA. And that was the primary lack that the Seedkeepers suffered. They could look, but they couldn't touch. They could swap steplings and pups, arrange marriages, and manipulate genetic strains to preserve wisdom to the extent possible.

But it was always a crap shoot. Over the long run, trends were manageable, but the chamalian gene-strain was always unpredictable from day to day, from tribe to tribe, from clan to clan, from breed to breed.

Until now.

Jerome was in a position to change all that.

The red monkeys gave Jerome a staff—two desert cats, a digger from the equatorial belt, and a blue marmot. To Jerome, they were just useful hands with strange faces and fur. The chains

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came off, but Jerome and the rest of his crew were confined to the workshop. Yulish organized the living arrangements, and the chamalians set up housekeeping at the far end of the room from Jerome's digs.

The monkeys gave him tissue samples, sealed and labeled, according to his specifications. The assistants processed them and put them into the gene machine. The gene machine analyzed them, produced a genome map, and filed the data away.

And they gave him genealogical records. That left Yulish shocked—and worried.

"They have never in two hundred years revealed that data. Not even to the Seedkeepers. The red monkeys never tell anyone outside the enclave anything about themselves. We do not even know how many of them there are."

"I guess I'm a more talented negotiator than I realized," Jerome said.

"It's not that," Yulish said. "I am afraid. Very afraid."

"But why?"

"Because if they let us know these things, they will kill us all rather than dare to let that knowledge out of their hands."

Jerome frowned and let the breath sigh out of him. "I didn't need to know that," he said.

Nevertheless, he studied the records. They went back to the escape from the Rift Valley and covered every red monkey that had lived since then. Jerome put Yulish in charge of entering them into the AI.

Jerome spent his time working with the AI and the mindpad, building up his understanding of the red monkey gene strain. It was hard, repetitive, tedious labor, but Jerome knew what he was looking for. He was the only creature on the planet who knew.

He had decided against telling Yulish about his discovery. It would have put her in danger, risked his own life, and served no purpose but to satisfy his vanity. No, the only way he would survive this ordeal would be to keep his cards close to his chest and play them carefully.

He did set down notes on the mindpad, even though he had trouble with the keyboard. He kept skipping the "A" and the "Q" and the "Z" and the left shift key. At some point, he would have to learn to use a different finger for the shift key, but he was too busy for that right now. In the meantime, he at least had recorded his work in case something happened to him.

And he had been given an opportunity to work out the proof of his discovery in a way that no ordinary geneticist would ever see.

On the eighth day of his captivity, Jerome was visited once again by Kwi-lo-rak Do-sha-man-kay. Once again, the elder was escorted by Shorty and his band, and once again he clambered up the woodwork to get a better vantage on the human scientist.

"You have had eight days to study our seed," Kwi-lo-rak said. "Now what are you going to do?"

Jerome was slow in answering, to offset the quick words and impatient attitude of the red monkey elder. Besides, he didn't like being pushed and he didn't like being rushed.

"Why are you in such a hurry?" he asked. "Science takes time."

"They tell me you angels live long lives," the red monkey said. "That's a disadvantage on this world. Things move too quickly to take time. Our lives are too short and the consequences of our actions follow them too quickly to give us that leisure. We cannot afford to wait on your science. Tell us now what you are going to do. Tell us what you are going to do tomorrow to reach your goal—and survive to see another day."

Jerome drew a deep breath. "Okay," he said. "I haven't learned everything I need to know about your gene-strain. But there are some things I can do im-

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mediately. If you want, we can try cloning. The equipment is simple enough. The process should be easy. The host mothers can belong to any breed. I could begin working on that tomorrow."

"Cloning? That's not a word I know."

"Professor, could you explain it to him?"

"(It's on the list of proscribed technologies)," the Professor answered. "(It cannot be explained. Your attempts to do so will not be translated.)"

"Great." Jerome felt ill.

Then he had a flash of inspiration. "Yulish, come here. I need your help."

Her understanding of English was still rudimentary, but the concepts were easy for her. They had been, after all, the main business of the Seedkeepers for two centuries. After a few minutes, Kwi-lo-rak had a rough idea of cloning. Very rough.

"And what equipment would you need?" he asked.

Jerome was seized with sudden excitement. Any grad student in genetics could answer that question. He could use a variation on the Hawaiian method. It had been around for more than a century. Kids did it in grade school. You put an egg cell and a donor cell into a natural state of suspended animation, removed the egg cell's nucleus, nudged the two together, and zapped them with enough electricity to break down the cell walls, so they became a single cell with the donor's nucleus. Then you put them in a nutrient culture for a few hours. The end result was an embryo that could be placed in a surrogate mother and grown to term. The gene machine could do it for him in just a few hours.

"I need a sterile work environment. A supply of egg cells and a supply of donor cells. A supply of mothers. Refrigerators. A sterile work environment. Petri dishes—lots of petri dishes. How big a project are you planning? How many pups do you want?"

"As many as you can make," the red monkey replied, hopping from foot to foot on his perch in excitement. "A hundred. A thousand."

"A bigger staff," Jerome added, as the scale of their expectations hit home. "A microforge and a microbeveller to make micropipettes and a controllable very-low-voltage power supply. And did I mention a sterile work environment?"

Jerome felt more confident as they discussed the details. Yulish had a hard time with some of the terminology, but with some repetition and explanation, she got his message across. The chemistry would be the hard part, but Alyska Spenskaya had already done lots of work in that area and he knew the chamalian substitutes for HEPE-CZB and cytochalasin—and the gene machine could produce substantial quantities of them.

"Very good," Kwi-lo-rak said. "Now you will see the way the Red Monkey works."

The next day, he did.

First they brought him a glass blower, a puffy-cheeked rodent with a long fluffy tail and long delicate fingers. His name was Yap-chorl. With Yulish's help, Jerome described a microforge.

"It's an all-purpose tool," he said. "You put together a microscope, a micromanipulator, and a platinum-iridium filament. They made us work with them in grad school. We had to make our own micropipettes. You're also going to need a microbeveller—that's just a tiny grinding wheel. A puller would come in handy, too."

Yap-chorl's eyes widened in disbelief, but then he looked furtively at the armed guards on either side of the door and began to pace. After a moment, he clenched his hand into a fist and held it aloft.

"He's got the idea," Yulish said. Jerome was only a little surprised when a team of broadbacked slaves carried Yap's tools and equipment into the

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workshop and set them up in the corner.

A short time later, another team of slaves showed up with three microscopes. One consisted of a brass tube cradled in a polished wooden frame, another comprised a wooden tube set in a brass cradle, and the third was made entirely of glass, frosted on the surfaces, but clear at the ends. By the end of the day, Yap had transformed them into three working microforges.

The next morning, the red monkeys brought eight more glassblowers to learn how to make microforges. The glassblowers were all nearly identical in form and color, and with their big eyes and their long, delicate fingers, they reminded Jerome of lemurs. Yap-chorl said they were all cousins, descended from some forest tribe. Someone brought in more microscopes, and by the end of the day, Jerome had eight more microforges. And Yap-chorl had built a microbeveller.

In their spare time, the lemurs set up a glass furnace and began making petri dishes.

Jerome had a go at explaining again to their red monkey guard the need for a sterile work environment, but that was a little harder to do. The guard wasn't really interested in the concept, had no authority to implement it, and wasn't even certain if he wanted to pass it along to Shorty and his great-uncle. Jerome made a mental note to pursue the point the next time he saw Shorty.

The next day, he began teaching Yulish and a nimble-fingered ferret with yellow fur how to remove the nucleus from a donor egg. He used the gene machine because it was more reliable, but Yap was beginning to turn out micropipettes that would do the job just as well. They picked up the technique quickly, and with a few hours' practice they were as good at it as Jerome. Once they got in a few hours on their home-built equipment, they would be proficient enough to begin teaching others.

At the end of another day, eight more chamalians had mastered the technique and were ready to teach sixty-four the following day. Another sixty-four technicians had arrived to learn how to produce micropipettes, and Yap was teaching eight how to make microbevellers. And petri dishes were piling up all over the place.

The next step would be to organize the cell samples and plan the procedures required to collect eggs, produce the clones, and implant the eggs into the donor mothers.

And that required another audience with Kwi-lo-rak. Jerome and Yulish explained their needs to the guard and impressed upon him the need to talk to his leader. But like the request for a sterile work environment, they weren't sure if he understood them or was willing to help.

They got their answer that night.

Jerome was still up. He normally worked around the eighteen-hour chamalian day and slept every other night, letting his circadian clock run out to the long end of its range.

There were enough chamalian workers now in his small domain that the smell of their bodies filled the air and the sound of their snoring rattled the windows.

These small hours of the short chamalian night were hours of pleasant solitude. His only company was a pair of nocturnal wood-hogs, who spent the time cleaning things up. Alone with his thoughts, Jerome reflected on the subtle revenge that lurked beneath his apparent collaboration.

He knew just what a crap shoot this method of cloning really was. Substituting the nucleus of a somatic cell for that of a fertilized egg was fraught with hazards. Germ cells were primed to develop into an entire creature. Somatic cells were not. Hidden flaws crept into the code; flaws that prevented lungs from functioning, hearts from circulating

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blood, cells from metabolizing proteins and sugars and fats—flaws that could remain hidden for years. And, he hoped, flaws that the red monkeys could not link to him or his methods.

That would be a new wrinkle in the Red Monkey tale. Jerome smiled at the thought. In the midst of the Awakening, the monkeys all start to die from multiple unknown physiological failures. The Angel's Curse, they could call it.

Suddenly the doors flew open, the lights all flashed on, and a dozen armed red monkeys spilled into the workshop. Shorty followed the squad, barking orders as usual, and they roused the workers.

He hopped onto the desk and confronted Jerome face-to-face. "I have vital questions that you must answer immediately," he said.

"Ask anything you want and I'll answer you as well as I can."

"About cloning: is it true that you are producing identical copies of each red monkey who donates his cells? Identical seed?"

"(These are proscribed subjects)," the Professor said. "(I can't participate in this discussion.)"

Jerome cursed and called for Yulish. She answered from somewhere behind him, but didn't dare move closer while under guard.

"Yes, it is true," Jerome said, and Yulish relayed his answer.

"You should have told us this earlier."

"I thought we did. Yulish, didn't you explain that to them?"

"Yes, Angel Jerome," she said. "Though I may have left that detail out of my explanations—until today."

"This is unacceptable," Shorty said sharply, Yulish and the Professor both offering a translation of his chittering remarks. "You cannot do this. Under the Laws of Cha, this is an abomination."

Shorty barked some orders, and his squad began assembling the workers that Jerome had trained. Barks, growls, chirps, moans, and howls filled the loft as the red monkeys prodded the slaves into motion. One of the slaves was slow to awake and voiced a loud objection. Shorty pulled a pistol from his belt and aimed it at the worker. Jerome gasped. Shorty pulled the switch and the pistol belched fire with a loud bang, knocking the worker lifeless to the floor.

"Hey, that was totally unnecessary!" Jerome yelled.

He felt his head suddenly jerk to the left, then pain filled the space where it had been. Someone had clipped him from behind, and the blow was enough to put him on his knees.

No one else fired a weapon, however. Shorty had taken a life to make a point with the others, nothing more. Jerome was furious.

Silence fell over the work force as the squad shackled them to one another, then Shorty ordered them out of the workshop. They filed past Jerome and out the door, some looking down at their fallen comrade, others looking straight ahead without response.

When all were gone and only Jerome and Yulish were left, the rest of Shorty's squad turned to the glass-blowing furnaces and the microforges. Some of them fired their weapons into the equipment. Some grabbed lumber from a corner and used it to smash the pieces into the floor. The petri dishes made a musical sound as they shattered into shards. It took only a few minutes to destroy the week's work.

Jerome had a sick feeling in his stomach. He wasn't afraid that he would be killed. Worse than that had already happened. He had been betrayed. And not by the red monkeys, but by his own naive optimism that he could bargain with them.

They cared nothing for his work, nothing for his efforts. Their purposes were beyond his and they owed him no respect. He realized now that he never should have given his trust to these creatures, since it was not fairly earned.

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He would not make that mistake again.

Shorty returned later that afternoon. He was accompanied by a single armed companion.

Jerome and Yulish sat alone in the empty workshop, Jerome in a chair he had fashioned out of some scrap lumber and Yulish perched atop his desk. The silence was a raw reminder of Jerome's betrayal, every drip from the water tap echoing off distant walls.

Shorty talked with Yulish, explaining what had gone wrong, and she passed his words along to Jerome.

"The red monkeys believe in the permanence of identity," she said.

"Permanence of identity?" Jerome asked.

"Yes. From each Awakening to the next. Each time the Red Monkey awakes, the sleeping soul of each red monkey is reborn. But the problem is that there are only so many souls. When they are all used up, it signals the end of the Awakening and the return of the long dream. That's when the tribes start to fight with one another, fearless of death, secure in the knowledge that they will return the next time the Red Monkey awakes."

"That's just reincarnation. What an absurd superstition," Jerome said. "How can an advanced, intelligent species believe such a thing?"

"Because on Chamal, old ideas are as tenacious as old genes," Yulish said.

"Of course," Jerome said, recognizing the perversity of the world that was becoming more familiar to him every day.

"It is worse than that," Yulish said.

"How can it be worse?"

"Shorty says he has no use for us now. He says the red monkeys cannot break the Laws of Cha. He says he must decide now what to do with us."

"He does, does he?" Jerome asked. Fear, panic, and outrage struggled within him. He had his suspicions about what the red monkeys did with captives who were no longer of use—and releasing them was not one of the alternatives. But he couldn't believe they would make such a mistake. "Then you'd better tell him he's wrong."

"Wrong?" Yulish said. She cowered briefly, and Jerome realized that telling a red monkey that he was wrong went against her instinct for self-preservation.

"Let me tell him, then," Jerome said. "You can't be serious, Shorty, can you? Do you think cloning is the only way there is to fix your screwed-up genetics? Do you think I'm such a crummy geneticist that I can't come up with something else? We're just getting warmed up. You have no idea how many other choices we have: gene-splicing, recombinant DNA, direct manipulation of the gene-strain in the germ cells themselves."

Jerome felt his face grow hot. His heart pounded in his chest and his hands began to sweat. He paced nervously back and forth as he spoke.

"Don't you get it, you pathetic little murderer? I am an angel. I have powers of science and technology beyond your wildest dreams. I am a freaking magician when it comes to genes, and you ain't seen nothing yet. You tell me the Laws of Cha, and I'll tell you ways to work around them. You tell me what we can't do, and I'll tell you what we can. Just quit screwing around, quit threatening me, and let me show you my stuff."

Shorty and his companion had backed closer and closer to the door as Jerome grew more animated. Now they stood in stunned disbelief. The Professor had kept up with Jerome's tirade, translating everything but the technical terminology.

The red monkeys chattered briefly with one another, then Shorty motioned Yulish over. He talked to her for a moment, then put his hands on his hips and glared at Jerome.

"He says he will tell his elders what you have said. And he apologizes for un-

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derestimating your wisdom. That is very unusual, Jerome. Red monkeys never apologize to another breed."

"I'm not another breed," Jerome said. "I'm an angel. Are we out of danger here, or is he yanking our cord?"

"It is hard to know," Yulish said. "I am not sure if he knows. Internal red monkey politics are very complicated. Very fluid. But he seems confident, and I think that is a good thing."

"I hope so," Jerome said. "But if it helps, you can tell him that I'm not bluffing. I can do everything I said and more. He doesn't know it, but he and his friends kidnapped the only creature in existence that understands how your crazy genes work. You didn't know that, did you? Well, it's true. I've figured it out. I haven't told anyone yet, but I've figured it all out. And if I have to use everything I've figured out to keep us alive, I'll do it. And you can tell him that."

Jerome awoke slowly the next morning to horizontal sunlight coming through the window and a rising roar of machinery in the courtyard down below.

He heard it begin as dream merged with reality, before he had his wits about him. The growling of a single fossil-fuel engine, it was joined by another, and then another. In his dream, the engines were reproducing, and at a prodigious rate. At some point he lost track of the new arrivals, and the sound just continued to grow until it was loud enough to wake him.

He rose to his feet and stumbled across the workshop to the window. He had to balance on the sill and turn his head sideways to see through the narrow strip of glass to the square below. It was filled with vehicles—several dozen large trucks, their engines loudly pouring blue smoke into the courtyard.

As he watched, chamalians—red monkeys—began to gather around the trucks, filling the streets and the courtyards and the alcoves. Each of them, old and young, large and small, male and female, carried some kind of bag or basket. Red monkey leaders sat on the shoulders of overmuscled chamalian giants nearly two meters tall and directed traffic. Periodically, at their loud command, a family of red monkeys would scramble across the square and fill up one of the trucks. One by one, over the course of an hour, the vehicles were loaded. When all were finished, their drivers put them into gear and rolled them down the street and out of the square. It took half an hour for the last of them to find its way out.

"Where are they all going?" Jerome asked Yulish at one point in the process, but she had no answer.

Jerome returned to his desk, worked on his notes, played solitaire, and had the portachef transform some straw and chamalian sausage into a grilled cheese sandwich. Three hours later, when the sun was high in the sky, the trucks returned. In another hour, they were loaded once again and they headed out of the square. They returned three and a half hours after that, just as the sun was setting and Jerome was trying to coax a bowl of clam chowder out of the portachef. He was still up and awake when they came back again in the middle of the night.

Yulish was also awake when the trucks returned. She was too worried to sleep. Her wiser voice had its drawbacks. In a moment of crisis like this, it could become more of a burden than a blessing. She was plagued by terrible unanswerable questions.

The departure of so many red monkeys could not go unnoticed in Suridash. What would the rest of the city think of it? What would they do? Would they do anything at all?

And what would the angels do?

Ever since the arrival of the angels, Chamal had existed in a perilous moment, suspended over an abyss of

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doom.

Yulish knew the awful moral truth that burned in the heart of every wise creature of Chamal—that their race was cursed by nature and an abomination in the sight of god. God, the old myths claimed, had fled Chamal after being attacked and raped by its wild creatures. The Seed of God had given chamalians wisdom, but with it came a curse—the ability to imagine a moral purity that they could never attain. They saw themselves as flaws, as freaks, as cosmic accidents unwanted by an orderly Universe.

When the angels arrived, all Chamal knew without questioning that the end of the world was at hand. Overnight they dropped their ancient hatreds, their political struggles, their drives for conquest of their neighbors, and bonded together to defeat the foe.

Except that the angels had prevailed, without any effort on their part, when the fragile unity of the chamalians shattered at the moment of first contact. In the aftermath, the angels gave her world a choice: End all political violence at once, or be destroyed. Chamal had chosen—narrowly—to put down its weapons and continue its existence. The angels had, in turn, shared the wisdom of their pure race, in the hope that it would enable Chamal to restrain the impulse of the wild to overcome wisdom.

But now that the red monkeys were on the move, Yulish realized with sick dread, the angels could be forced into a decision they didn't want to make. If the monkeys were going where she suspected they were going, she didn't see how they could avoid a fight.

And that would surely bring the angels into things.

Being a good chamalian, she was saddened by that thought, since there was no doubt in her mind that if the angels came calling on the red monkeys, the first thing they would do would be to get rid of the evidence of their crime—her and Jerome Sullivan.

The sky was beginning to glow when her wiser voice expended itself and she finally fell asleep.

The trucks came and went again the next day. And on the day after that, Shorty returned.

This time he accompanied a new red monkey leader, younger than Shorty's great-uncle Kwi-lo-rak, with bristly whiskers and strokes of gray in his fur. He scrambled up a stool and paced on top of a workbench, his tail twitching behind him.

"I am Pok-no-ri-lak Yo-nik-la-ray. I am cousin to Shorty's father, nephew of his great-uncle past. You are to prepare to leave this place. You will be departing in the morning. Bring your personal equipment with you. Your larger machinery will be taken care of."

"Where are we going?" Jerome asked.

Pok-no-ri-lak leaned back in astonishment at Jerome's question. He turned to Shorty and asked: "Is this one allowed to speak to us?"

"He is an angel," Shorty said. "No one has suggested that we try to stop him."

That gave Pok something to think about, and he spent some time at it as he ran his eyes over Jerome and leaned forward for a closer look. "I'm not sure I like it," he said.

"You'll get used to it," Jerome said. "And you haven't answered my question."

That set Pok jumping up and down, barking in the secret red monkey dialect. Shorty looked at Jerome, then at his father's cousin, and waved his arms in the air. Jerome wasn't sure what the gesture meant, but Pok gave him some idea when he said: "Shorty refuses to end your life for your impertinence. He says it will bring great destruction to us all. I have no choice but to believe him."

Jerome swallowed hard and tried to ignore the realization that his fate had been just debated and determined by

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the two red monkeys. "Does that mean you're going to tell me where we're going?"

Pok hissed and rubbed his face with his hands. "We are going home," he said. "And we are bringing our valuable property with us. You included."

The ship was a splash of color—yellow, orange, blue, and red—sandwiched between gray clouds and a gray sea. Jerome stood on the pitching deck of the bridge, at the stern of the vessel, watching three distant blue-gray shapes edging over the horizon. Captain Melkonia stood a couple meters away, watching the same thing. He was big for a chamalian, with sleek silver fur, a thick brown moustache that covered a deeply cleft upper lip, and wide, flipperlike hands.

Melkonia spat a word into the wind, and the Professor whispered in Jerome's ear: "Pirates!" Jerome felt his breath catch in his throat, then forced himself to inhale. They were equipped to deal with pirates, weren't they?

Jerome had had enough of the ship. They could throw him over the side any time they wanted. He was finally beginning to recover from the nausea induced by the motion of the sea and the smell of hydrocarbon exhaust, and he still relied on the brisk wind to relieve the miasma.

He had come up to the bridge because from here he could watch the ship as it slowly climbed one tall wave, wallowed briefly at the crest, and then slipped down the far side—over and over again. It was preferable to being confined below, left to experience the ship's forward advance as a combination of simultaneous pitching and rolling, with all its complicated moment arms and cross-accelerations. He couldn't even play solitaire down there.

So he escaped to the bridge and watched the slow progression of weather across the chamalian ocean. In the three days since they'd left Suridash, Jerome had seen a day of blistering sun, a day of gale winds driving whitecapped waves before them, and a day of steadily rolling seas beneath an ashen sky punctuated by intermittent rain squalls.

One such squall swept onto the deck now, forcing Jerome and Melkonia into the shelter of the deckhouse. Inside, the helmsman—a green-and-yellow tree bear with robust arms and shoulders—tended a mighty tiller of dark wood wrapped with bands of iron. The navigator—a brown-furred beast with buck teeth and a wide, flat tail—pored over charts on a table in a corner lit by a single bare light bulb.

Captain Melkonia clomped up and down the deck with heavy boots, swung his tail back and forth with menacing energy, and cursed.

"Oil and vinegar!" The Professor translated.

"Oil and vinegar?" Jerome asked.

"Those are the words," the Professor replied.

"They must have a different connotation for a vegetarian," Jerome said.

Jerome and Melkonia had come to know each other surprisingly well in the few days of their voyage. The captain had allowed him onto the bridge, and had told him his life story. Melkonia was a native of Rikat, the largest of the trading states that once formed the Rikabarian Empire at the far western end of the ocean. He was a lifelong member of the Royal Onion Party and had been a commissar on the day the angels arrived. That was the day that the empire fell, that the party dispersed, and the world had turned upside down.

Until that day, Melkonia had spent his time in port hunting down pups and halflings with carnivore traits and hauling them off in the Rikabarian equivalent of ethnic cleansing. If the party had been allowed to carry the program through to completion, with discipline and commitment, he insisted loudly, all carnivores would have been eliminated

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from the gene pool within a generation, two at the most.

The angels had put an end to that with their simple decree. No more mass exterminations. Not of the wise, not of the wild. No more organized political violence of any stripe or hue. If the uprising against the Royal Onion hadn't put an end to the party, the decree would have. How else could they maintain their power if not through violence?

So Melkonia had returned to the sea, resigned to the fate that his race had suffered: to be held hostage by well-meaning purebred aliens.

"Oil and vinegar! Vinegar and oil!" he bellowed. "They grow closer and closer with each wave. We cannot outrun them. We will have to fight. Cursed monkeys!"

"Why are you cursing the monkeys? It's not like they invited the pirates to attack."

"It is!" bellowed Melkonia. "Just like them, it is! We have a choice—open sea or close to shore. The cursed red monkeys say sail close to shore. I do not like it, but they are afraid eyes in the sky will see them."

"You mean observation satellites?"

"Exactly," Melkonia replied. "The creatures of the Rift Valley fear the return of the Red Monkey more than anything. They watch and they wait. But they are there and the pirates are here. Oil and vinegar! Cursed monkeys!"

Jerome gritted his teeth and braced himself against the rolling of the ship. He didn't know if Melkonia and the monkeys could defend themselves from the pirates, but if they couldn't, he hoped the pirates would be amenable to bargaining with an angel.

The attack came only an hour later and was surprisingly brief. The pirates announced their arrival with a barrage of small rockets, which burst with gouts of fire and a loud *BANG-BANG* just aft of the deckhouse. They boarded quickly and were all over the ship. Then armed parties of the ship's crew, aided by Shorty's honor guard, popped out of ambush and swept the decks clear.

Jerome thought it was all over when suddenly one of the pirates—a big beast, resembling Melkonia, but for a pair of long straight tusks that projected down from his moustache—appeared only a few meters away at the top of a ladder from the main deck. Jerome stumbled backwards. The pirate carried a large handgun with smoke still lingering around the tip of the barrel.

A wave of panic swept over Jerome. He was afraid that the end had come, full of fury and malice. He regretted ever daring to think he could solve the secrets of nature, afraid that no knowledge was worth the empty death that awaited him, full of despair over the loss to science that would accompany his demise.

Then Melkonia appeared at his side. He reached under his coat, produced a heavy pistol of polished metal and wood, and fired it at pointblank range, sending the pirate flying backwards down the ladder.

Then there was silence, but for the sound of the wind in the rigging and the waves breaking into foam. Jerome was too frightened to relax, but there seemed nothing else to do. Melkonia rushed to the other side of the deckhouse, then returned.

"We won!" he shouted. "They leave us now as fast as they came!"

Jerome watched the small craft skipping across the tops of the waves as the pirates made their escape. The deck gun fired one last time, raising a mighty splash in the wake of one pirate boat, but allowing its passengers the grace of a narrow escape.

"Yes, we won," Jerome said, speaking so softly that only the Professor could hear. "But are we any better off for it?"

They suffered another pirate attack during the night, but repelled it with small arms and a marginally effective deck gun. A third attack, shortly after

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dawn, was foiled when two more ships of Melkonia's fleet appeared out of the morning haze and combined their fire with his. Jerome spent the night in the deckhouse, where he slept fitfully, sitting on a rough wooden stool in the navigator's corner. The exchange of fire woke him, and he watched the attacks evolve from Melkonia's side.

By midmorning, they were sailing under a bright blue sky, with gray humps of land rising ahead of them. Before dark, they were among the channels and straits of the Broken Lands, which marked the western terminus of the Rift Valley. The rocky islands were rimmed by cliffs that rose straight up from the sea for hundreds of meters, scarred by wind and rain. Clumps of bright green vegetation clung to crags and outcrops, and screeching winged halflings circled their high perches.

Melkonia was called belowdecks by his crew, leaving Jerome alone for a while. He took the opportunity to duck into the captain's cabin and order a mug of coffee from the portachef. When he returned to the deckhouse, Melkonia was in a foul mood.

"Rotting fruit!" he cursed. "Sour wine! Those bloody butchers. They don't care about who has to clean up after them."

"What's wrong?" Jerome asked.

"Your bloody red monkeys," Melkonia said. "Decent creatures know how to take a life. A small bullet to the head and it's all over. Clean. Not a big bloody mess. Carry them away to the fertilizer plant. But those monkeys are awful."

"I don't understand," Jerome said, fearful that he did understand.

"A bloody purge. During the night, the monkeys killed their clan leaders. Cut their throats in their cabins. Blood all over the decks and the walls. It's a stinking mess. And they refuse to clean it up. They told us to throw the bodies over the side. Told us that they were unclean refuse. Their own clansmen. No honor among those beasts. No true wisdom. Never again will we deal with them."

A purge? Jerome was dumbfounded. What would spark the red monkeys to conduct a purge? Why would they kill so many of their own? And who had been liquidated? Shorty? His cousin, Pok-no-ri-lak? Is that what had happened to Shorty's great-uncle Kwi-lo-rak? What would happen to him without Shorty around to protect him?

That evening, to Jerome's relief, Shorty appeared in Melkonia's cabin, escorting a new red monkey leader. This one appeared younger still than Pok-no-ri-lak, limber and bright, leaping quickly onto the table to confront Jerome eye-to-eye.

"I am Mo-nak Lop-ri-ral, cousin to Shorty," he announced. "We want you to know that we respect your cha, but it is necessary to keep you hidden when we arrive tomorrow in Tang Do Rak. You will leave the ship under cover and be taken in a closed truck to the Palace of Burning Rabbits. Once there, we will give you an opportunity to show us that the things you promised Shorty back in Suridash are more than empty boasts."

Yulish was astounded by the rise in status they acquired when they arrived at the Palace of Burning Rabbits. It was the last thing she expected after a harrowing ride through the city in the back of a covered truck.

She was able to see through the cracks in the truck canopy and what she saw made her heart sink. Smoke from dozens of great fires smeared the horizon, black and ugly. Large groups of chamalians gathered on street corners, and though she could not hear them speak, nor understand them if she could, their angry gestures as they spoke made her fear for her safety.

Then, as they drew closer to the palace, she saw the clashes between the red monkey overmasters and the crowds that gathered in the open spaces. The way the overmasters, tall

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and muscular, beat back the mob of creatures in their path with long wooden poles made her hearts clench.

It wasn't exactly war—the overmasters were careful to avoid lethal force—but it was violence and it was political. If the angels objected to it, her whole world could be forfeit.

Yulish had expected to be locked away in some grim red monkey fortress somewhere beneath a distant hilltop. It seemed the only safe place to hide from the discord in the streets. But the Palace of Burning Rabbits was in the center of the city, surrounded by gardens, lakes, canals, and parks.

The first batch of the red monkey returnees had seized the palace, which the squirrels and badgers and otters and climbers and fishers that controlled the city had transformed into a university. There was no armed resistance, and the students had scattered before resolute squadrons of red monkey overmasters.

The next batch headed into the hills to open the hidden caches where their ancestors had prepared the way for the next Awakening, where they found weapons great and small, ordinary and terrible, and gold and jewels beyond imagining. For now, the weapons remained sealed in the armories, but the vaults poured open. If the angels would not let the red monkeys shoot their way into power, it might still be possible for them to buy their way in.

The truck passed through one final clashing demonstration, the growl of hundreds of enraged chamalians grabbing at her hearts, then raced through the high iron gates and into the palace grounds.

Once inside, she and Jerome and all his equipment were taken down long corridors, past rooms filled with books, past piles of books spilled across the floors, past grand apartments transformed into lecture halls, deep into the maze of hallways and passages—but no stairways, since the palace was laid out on a great, level plain—to a set of grand apartments and workrooms on a scale she had never imagined possible in her years of study in cramped Suridash.

Jerome had his own suite, with running water, a library, and electricity. She had rooms of her own to match. Servants were assigned to them. Guards, too, since it was clear that despite the luxury, they were still prisoners. They even had a garden outside their rooms, with enough grass to feed a herd of grazers—an extravagance beyond belief to Yulish, a child of the desert.

They were ignored for several days while the struggle to subdue the city continued. The smoke from burning buildings got worse, the stench clinging to the walls and to her clothes and fur, then it got better, then it ended.

Sometime in the middle of this period, Yulish approached Jerome. He was sitting on a pile of cushions, playing that solitary game with the mindpad.

"I must know, sir," she said, trying not to plead. "You said you had solved the secret of chamalian genetics. Is this true? Have you discovered something new that the other angels do not know?"

Jerome set aside the mindpad, sat up on the cushions, and looked about. When he was sure no one was near enough to hear them, he nodded, which Yulish had learned meant assent.

"I am afraid it's true," he said. He told her how he had been reveling in the moment of discovery when Shorty and his band kicked in the door.

She asked: "Are you sure of what you have discovered?"

"Very sure, Yulish," Jerome said. "When I have more time, I will explain it to you. But first, there's another subject I want to research, and I need your help."

Yulish tingled at the suggestion of a research project. But when Jerome told her what he wanted, she was only puzzled. He wanted her to help him decipher the genealogical records of the red monkeys of Suridash, which she had

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transcribed into the Wise Teacher of the Wise.

For most of a night, they went through the records. Jerome called them "family trees," and Yulish could see where the branching diagrams he drew on the smart board quickly resembled the limbs of a tree.

"What do you know about internal red monkey politics?" Jerome asked, as the pale yellow glow of dawn crept into the sky.

"Little. More than when we left Suridash. What exactly do you want to know?"

"When someone makes a mistake, a bad decision, what happens? Exactly?"

Yulish trembled. This was knowledge she had meant to keep away from Jerome. Her wiser voice reminded her that he was still an angel and still represented a great threat to her world. Revealing the bloody habits of the red monkeys to an angel did not seem well-advised to her. But he already seemed to know the truth.

"When one of the clan elders makes a bad decision, he is killed," she said.

"Is that all?"

Yulish's hearts clenched. The angel knew the whole truth—or suspected it.

"And all his line with him, sons, grandsons, great-grandsons. It's to guarantee that no one of that line will make a similar error."

"No wonder Melkonia was so pissed off," Jerome said. "That must have been quite a bloodbath on his nice clean ship."

"Sir?" Yulish asked.

"It's a long story," he said. "But you can see it in their genealogy. It's there, over and over again, especially in the early records. They keep cutting up their pedigrees, wasting their male heirs like they had an endless supply. No wonder they believe in reincarnation. They have to."

"Yes, I suppose so," Yulish said.

"Well, good for them," Jerome said. "At last we have a weapon to use against them."

"A weapon?" she repeated softly. Jerome seemed pleased by the thought, but Yulish was not. Her hearts squeezed tight and her fears only grew stronger.

Jerome was still stymied by the lack of a sterile work environment. The chamalians as a race didn't quite understand the concept. Part of it was the dismal state of chamalian medicine. For all intents and purposes, there was none. There were herbalists who knew what native drugs and potions to use for what ailments, and there were surgeons ready for the service of removing an injured or infected limb. But there was little motivation among the intelligent members of the chamalian race to relieve suffering or prevent disease—despite lessons by their human teachers intended to remedy this empty slot in their historical experience.

So he had to create one himself. At least the chamalians were quick to provide him with whatever materials he requested. He discovered that they could produce large quantities of translucent plastic sheets and a smelly but powerful glue. Prowling about his quarters, he found a marble-tiled bath with a fountain in the corner and pools set in the floor. He draped the walls with plastic and fixed it in place with the glue.

The monkeys provided him with rough-surfaced, green, wooden poles, which he used to support a plastic awning. He hung double layers of plastic across the entrance to create a trap. He had three large tables of polished stone moved in for use as work tables.

Finally he requisitioned large supplies of grain alcohol, which arrived in small clay amphoras, and used it to disinfect the entire compartment, the linens, his clothing, the gene machine, the AI, the smartboard, the mindpad, and three new microscopes, each of a new and different design from those lost back in Suridash.

While he spent his days outfitting his

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workspace, he spent his nights researching the red monkey family tree.

"I don't understand it," he told Yulish one evening. "The red monkeys are all a bunch of selfish, self-centered bastards. How can creatures so narcissistic be so ready to risk the sacrifice of their lives and those of their sons and grandsons?"

"They all think they are right, so they don't recognize the risk of being wrong," Yulish said.

"Perhaps," Jerome said. "But I can't help but think there's more to it."

"They believe in their destiny," Yulish said. "Completely. There is no doubt in their minds, else they would consider the possibility that they are wrong. It is not a trait unique to red monkeys. There are few chamalian males of any breed who can resist the seduction of a fate greater than their own."

"That sounds more like it. It has to be powerful enough to sustain in the face of figures like these," Jerome said, motioning to the notes on his mindpad. "Look at this. In one clan in one year near the end of the last Red Monkey Awakening, six clan leaders were eliminated for their mistakes. And with them went a couple dozen sons, more than fifty grandsons, and a dozen more great-grandsons. Almost one hundred males in a single clan. How many does a clan start with?"

When Yulish couldn't give him an answer, he went looking in the records. An average clan had three thousand members. But most of those were not red monkeys. They were lesser breeds with some hereditary link to the monkeys, who might some day be a link in the chain to a genuine red somewhere down the line. Only one member in ten was a legitimate phenotype. That meant there were only a few hundred red monkeys in the clan. That meant less than two hundred males.

And how many more were left in Shorty's clan? That was the crucial question.

Jerome tried to figure it out. They'd lost four leaders so far. Would that mean half the males in the clan had been eliminated? Even with Yulish's help, he couldn't come up with figures that he trusted. The hardest thing to accept was the utter devastation the red monkeys were inflicting upon themselves. Every time he tried to work it out, the numbers were just too high to believe.

Why didn't they stop?

Now he was finally beginning to appreciate the madness that lay at the wild heart of the chamalian race.

And that dark epiphany drove him to play solitaire for endless hours on his mindpad. Despite Alyska Spenskaya's accusations, solitaire was not an irrational distraction and waste of time for Jerome. It was one of the first tools he had been given to overcome his dyslexia. Mind patterning. Sequence manipulation. Those were the skills that he needed to strengthen, to master a disability of his brain to interpret sequences instinctively. And solitaire allowed him to practice and improve those skills.

That strength, and the drive to work out consciously the sequencing that his brain would not handle physiologically, had drawn him to the study of genetics in the first place. That was how he had come to be such an expert in sequencing genes and deriving information from statistical studies: recognizing patterns where others did not.

And now it had all come back to this, killing time by shuffling cards around on a screen.

He had improved his strategy at the gaps game. He tried to string sequences together wherever he could. The basic truth of the game was that nothing moved without leaving a space behind, a space that had to be filled by some other card. Each move opened an opportunity for a new move. Sometimes it allowed a long series of moves, as one sequence displaced another.

It could be quite elegant when the long chains ran through multiple trans-

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positions. Eventually, he found himself winning the game more often—once every day, instead of once every week.

He was quite excited when he found the game replicating the joining of chamalian nucleic acids as revealed by the gene machine. But he found himself growing more and more discouraged by the more common hands, where the chains ran out and the kings blocked further moves. What frightened him was the way that boundless opportunity turned so quickly into a bare handful of moves ending in failure, with no alternative play. What frightened him even more was the way the end could come so suddenly and unexpectedly. It was far too much like real life to suit Jerome. But he kept playing nevertheless.

He couldn't stop any more than the red monkeys could stop being who and what they were.

On the sixteenth day after their arrival at Tang Do Rak, Jerome was summoned to an audience with the newest leader of the clan that held him captive, a red monkey by the name of Ri-po-far Dar-lak-ap. The escort surrounded him and maintained some loose order, but no one threatened or coerced him. One carried the Professor with him, cradling it carefully to prevent it from going into safe mode. They were as much guides through the great labyrinth of the Palace of Burning Rabbits as they were guards.

He thought back to the first time red monkey warriors had led him through confusing chamalian architecture and the contrasts brought a smile to his face.

After a long walk and many turns down corridor after corridor, they arrived at the main hall of the palace. High-vaulted ceilings arched overhead. Tapestries hung from the walls, depicting great battles full of fire and smoke and triumphant red monkeys. An honor guard lined the walls, decked out in black velvet uniforms and armed with pikes four meters long.

At the center of the chamber, atop a raised dais, beneath a canopy of pink and red gauze, on a tall, ruggedly built wooden stool, sat the leader of the red monkey clan.

It was Shorty.

He must have assumed power from his cousin, Mo-nak Lop-ri-ral, sometime after their arrival in Tang Do Rak. Eventually, it seemed, every red monkey would rise to power—if his elders didn't get him killed first. For a moment, Jerome felt sad. If his plans were successful, Shorty would likely share the destiny of his predecessors. But his sadness was short-lived, as he recalled the red monkey's brutality, his casual murder that night in the workshop, and the initial crime that first brought them together and even now made his hand throb where his finger had once been.

"Greetings, Angel Sullivan," Shorty said. "Are you enjoying my hospitality?"

"Well enough," Jerome said. "I've finally got a sterile working environment."

Shorty bared his teeth and leaned forward on his perch, looking down on Jerome at last.

"Then you must be ready to go to work. Or has your work already begun? They tell me you have been very busy. Are you prepared to carry out your end of the bargain? Can you truly work the magic that you claim?"

"Certainly I can," Jerome said, narrowing his eyes in a suspicious study of the red monkey. The chamalian had changed. He was more composed and less volatile than Jerome had ever seen him. Power seemed to suit him well.

"Many red monkeys have died to get us here. Our numbers have grown thin. It will be very difficult to move beyond this precarious foothold without new blood, new strength. You must provide us with that strength. That is your promise, is it not?"

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"Yes," Jerome said. "I can bring you new blood. With the knowledge I have, it will be possible to awake the Red Monkey generations before its time."

"And you can provide me with the heirs I need to return us to power? To complete our destiny?"

"Yes," Jerome said, then he sighed. "I can provide you with heirs, and your destiny will be complete."

Shorty leaped to his feet, standing tall atop his stool-throne. His eyes widened and he bared his teeth. He rocked from side to side with barely restrained excitement.

"Then return to your apartments and get back to work. There is no time to waste. Move as quickly as you can. Ask for whatever you need. You will be denied nothing. If you have any desire, send a messenger to me and it will be met. The destiny of the Red Monkey is in your hands."

Indeed it is, Jerome told himself silently. Your destiny and mine, he added.

In the beginning was the Word.

It was sixteen syllables long and sixteen different syllables could be used to make it up. Each syllable comprised a string of letters written in DNA, pairs of guanine, adenine, cytosine, and thymine. All told, the Word could be spoken nearly 2×10^{19} different ways—a virtual infinity of possibilities. And it determined the destiny of every living creature that was born of the seed of Chamal.

Jobe had known about the Word. The secrets of chamalian genetics that he had derived from breeding frogs so many years ago were the secrets of the Word. The computations of the Seedkeepers were efforts to track its various pronunciations.

Alyska Spenskaya—who duplicated the frog-breeding tricks of Jobe—had studied the Word, but without ever knowing it existed. She'd built a powerful database that showed how the syllables shifted and changed generation after generation in their complicated chant and thereby laid the foundation for Jerome's discovery, but she had never guessed its complex simplicity.

Jerome, however, had seen it long before he ever came to Chamal. Without realizing what it was, he had heard it spoken in the shifting numbers and fluctuating patterns of the chamalian gene pool, captured and distributed on the academic cable network. It wasn't until he came to Suridash, however, and immersed himself in this world and its creatures, that he finally understood.

And solitaire was the key. Watching the cards shuffle and disperse, watching the simple rules of the game bring them back into order, that had spurred something in his imagination that put the pieces together. Mind patterning. Sequence recognition.

Like the human genome, the chamalian genome was a storehouse full of bits and scraps of unrelated junk that had accumulated over the millennia. Some of it was vital to the survival of the species, but most of it was debris that persisted because it is the nature of DNA to replicate itself. Large pieces of the gene code were left over from encounters with viruses and bacteria that insinuated themselves into the nucleus and remained there for generations, serving some obscure purpose or not. The Word might have started out as one of these.

The chamalian genome was different in that it kept more than one set of plans in that storehouse. With all the extra space, this was not a difficult bit of information storage, and managing the storage was the function of the Word.

It determined which of the genotypes would emerge when a zygote was formed. It set the limit on the evolutionary maturity of the creature. It controlled all the switches. Genes weren't blueprints, they were suggestions, explanations, decision trees, that from time to time told legs to stop growing,

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fur to change color, nails to curl and sharpen. And the Word worked its will whenever one of those decisions came up.

One set of syllables would produce a red monkey. Another set would bring forth a green tree cat. Another a blue ape. And like the kings that halted the sequences in Jerome's solitaire game, there were syllables that would stop the development of a creature before it reached its full potential, freezing it as a stepling, a halfling, or fully wise creature like Shorty, Yulish, and their kind.

In his speculative fancy, Jerome tried to imagine how the currents of chamalian seed could create a phenomenon like the Red Monkey. Clearly there were deeper switches involved. One syllable could be necessary for the next, and that one for the next, and the entire series could take generations to complete—a long series of words, a chant that went on for centuries, reaching its climax in the Awakening.

Jerome had tracked down the location of the Word within the chamalian genome. He'd caught his first scent of it in statistical analyses he had studied before coming to Chamal. He picked up its trail in Alyska Spenskaya's frog-breeding records and followed it through the records of the Seedkeepers. Using quantum modeling from the gene machine and statistical transforms from the AI, he had found its lair in the long, twisted chromosomes of the chamalian nucleus. And finally he had seen it at work in the syzygy of chamalian germ cells as they formed zygotes.

Now his task was simple. All he had to do was insert the Word for the Red Monkey into those zygotes and let chamalian nature take its course.

Yulish had made herself a new charm bag, sewn together from scraps of leather, filled with bones from frog soup, stones from the courtyard outside her palace apartment, and sticks from the strange plants that grew there. It didn't give her the kind of comfort she had hoped for, but it was something. She was sure she would need it before Jerome Sullivan's adventure had run its course. But as things turned out, she didn't have time to seek its comfort.

There was so much work to do, and Jerome attacked it like a desert cat devouring its prey.

For several days, Yulish was busy collecting material for his project. It was like the old days in the Hall of the Seedkeepers. First, she had to order dozens of wooden cages for them all. Then she had to dig through the red monkey records to identify what she needed. Finally, she had to round them all up and arrange for their caretaking.

In the end, she and Jerome had commandeered more apartments and created a menagerie of pups, steplings, and halflings, the castoffs of dozens of litters. The smell was familiar, but offensive to the nose.

Then Jerome set her on another, more daunting task. She had to accompany him as he collected what he called "tissue samples" from Shorty, though the red monkeys now called Ri-po-far Dar-lak-ap by his full name, and she was afraid to speak the appellation Jerome had given him.

Jerome seemed to take far greater pleasure from this job than seemed reasonable, though she knew that as a chamalian, she was in no good position to determine what might be reasonable. He bared his teeth throughout the operation, which involved slicing bits of flesh from Shorty's skin and placing them in small bottles. Each time Jerome made a cut, Shorty flinched and Jerome made a sound that reminded her of coughing, but which The Wise Teacher of the Wise had told her was something the angels called laughter—a sign of amusement.

When they were done and on their way back to their section of the palace, Jerome confided in her. "I didn't need more than one sample," he said. "But I

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just couldn't help myself. Payback is a bitch."

Yulish didn't understand the reference at first, but then Jerome waved his hand to show off the scar where his finger had been and she realized the revenge he had exacted. It frightened her more than it should have, but she knew what could happen if the red monkey learned that much of his suffering had been unnecessary.

That night, they spent hours in Jerome's workshop, his "laboratory." He revealed more of the secrets that the angels kept closely about the Seed of God and its inner working. The Wise Teacher of the Wise refused to participate, and she was left to struggle with Jerome's words on her own.

"Recombinant DNA."

"Polymerase chain reaction."

"Plasmid."

"Reverse transcriptase."

She learned much in the hours that they worked, with Jerome huddled over his gene machine. She was filled with an excitement and an energy that reminded her of the days of her adolescence when her brain was still growing and her wiser voice made its first appearance. And as she watched, Jerome revealed to her one of the miracles of the angels' science.

"We're duplicating a sequence of Shorty's genes," he said. "It's what I call the Word. It's what controls the destiny of every chamalian creature. I need copies, lots of copies. Making them is fairly easy. When we're through, I'll have a few million of them. Then we have to do the splicing and the implants. That'll take more time."

Yulish shivered at the thought. "But didn't we do something like this before?"

"That was straight cloning," Jerome said. "And you saw what the monkeys thought of that. This is splicing. We're just going to swap out the Word from the cells of the little creatures you've collected and replace it with a copy from Shorty. Then we put the new DNA into an egg cell and pop it back into the specimen."

It sounded so simple, but Yulish had a hard time getting her mind around the concept. She had grown more and more tired as the night wore on, and her thoughts were swallowed up by fatigue. Jerome seemed to thrive on the work, however, and on the strange dark liquid produced by his portachef that smelled like roasting woodnuts. But before long, Jerome announced that he had finished the job and sent her off to her room to get some rest.

She slept late the next morning, but was up and working again quickly. Now Jerome had her and eight new assistants working with the specimens. She and Jerome set up a regular workline, with someone fetching the creatures, someone else injecting them with anesthetic, Jerome working on them under the gene machine, with a magnified image of the creature's insides projected on the smartboard. When he was done, another assistant removed the creature and returned it to its cage.

That work went on for hours, until darkness crept through the windows and electric lanterns were switched on. Yulish made sure that everyone was able to take a break from time to time and saw to it that food was delivered periodically, but Jerome was impossible to manage and would not pull himself away from his machinery. Eventually, long into the night, he gave up, but only after making a mistake with an instrument that spoiled one of the specimens, an orange-furred stepling with down-covered wings.

Yulish helped him drag himself off to his chambers, then curled up on the floor at the foot of his bed to sleep. She awoke before he did, fetched him a breakfast meal from his portachef—with some help from The Wise Teacher of the Wise—and watched the alien food revive him. Then they returned to another day of intense labor.

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They went on like that for nearly eight days. When they were done, they had operated on more than a thousand red monkey offspring. When they told Jerome the numbers, he pulled away from his gene machine and sagged into his own bones like a specter that had lost its spirit.

"I hope it's enough," he said. "I hope we made enough."

Yulish fetched him a cup of his roasted woodnut brew and waited by his side as he drank it. After a while, he seemed to look alive again.

"How long will it be before the first litters are born?" he asked.

"Thirty-six to forty days," Yulish said.

Jerome looked off blankly into the distance, which Yulish had seen him do before, when he was numerating from chamalian to angelic figures. "Four weeks. Not long at all. Not long enough, if this doesn't work. At least I tried. Even Alyska Spenskaya can't say I didn't try. Yulish, you must take the time to prepare. You might have a chance to get away. You should be ready for an escape. We both should be ready."

"Yes, Jerome," Yulish said. She reached for the charm bag where it was tied to her belt and gently manipulated the contents. She didn't know what the angel meant or what he had planned, but it didn't reassure her. At least the familiar touch of the bag relieved some of the tension that gripped her hearts and her soul.

The waiting was the hardest part.

It took thirty-six days, but they were short chamalian days. Jerome took the time to rewrite his notes, adding in the work he had just completed, along with more complete commentary, things he had thought about at length since the kidnapping. He was even able to weave together a detailed hypertext, with connections to his diagrams, clinical data, chamalian records, micro-imaging from the gene machine, and even his customized solitaire game. All in all, he thought it was an impressive piece of work, something that would satisfy even Alyska Spenskaya.

He compressed the entire package into a single file, then copied it from his mindpad onto the smart board, into the Professor, and even into the portachef and the first aid kit. If any of his equipment survived him, his discovery would live on.

He expected the end to come swiftly and without warning, but even that simplicity was beyond chamalian capacities.

When the first of the steplings bore their litters, Yulish and the other assistants rushed to him with the news. The hours that followed flowed slowly as Jerome awaited his fate. He was certain that it would not be favorable. Once the truth was known, Shorty would want to know what had happened and why.

In that Jerome was not disappointed.

His only surprise was that Shorty himself came looking for him instead of sending his gunmen to fetch him.

Red monkeys simply were not large enough to storm through the palace. Doors did not slam open, furniture was not knocked aside, bellowing voices did not echo from the walls. If they had brought overmasters along, it might have helped. But as it was, Jerome's only warning was the sudden patter of a dozen small red monkey feet in the outer rooms of his apartment.

Then a burst of automatic gunfire shattered the repose of his private chamber.

Chips of stone splattered from the ceiling and bullets ricocheted into the papier mache walls. Jerome shut his eyes tight against the fall of rock dust, dived for the floor beside the piles of cushions that formed his bed, and tried to melt into the marble.

He opened one eye and looked over his shoulder to see Shorty framed in the doorway, a squad of his private militia behind him.

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The red monkey screeched loudly.

The Professor translated: "Treacherous angel, what have you done?"

He punctuated his demand with another burst of fire, this time aiming lower. Slugs whizzed by over Jerome's head and into the walls behind him.

Without rising a centimeter, Jerome answered him: "I gave you heirs."

The Professor's translated response squawked in the corner, drawing Shorty's attention. Jerome winced as Shorty trained his machine-gun on the device, but the red monkey held his fire. Jerome took the opportunity to roll over and sit up, facing Shorty at something approximating eye level.

"Heirs? Heirs? You gave me no heirs. Every single pup that has been whelped is a female! I have no need for daughters. Certainly not for hundreds of daughters. It is sons that I wanted."

"You weren't specific," Jerome said. "The procedure I used produces only females. If you had wanted only males, I would have done it differently."

"I am undone," he shrieked. "I cannot recover from this error."

"That was what I was counting on," Jerome said, regretting the words as soon as they left his lips. "Professor, don't translate that."

"(Too late,)" the AI said.

"You knew what you were doing? You betrayed me by design?"

"I knew what would happen to you if you made a mistake," Jerome said. "I was trying my best to get you to make one."

"You dog! You fatherless rabbit! You unclean changeling! Before I die, I will see to it that you suffer unspeakable agonies," Shorty raged. He turned to a lieutenant and said: "Make ready the apparatus of pain. And destroy the angel's workshop before he creates another abomination."

Jerome swallowed hard and sighed.

He considered his chances. If he tried to run, they might only disable him, offering additional opportunities for torture. But if he attacked Shorty straight on, they would have to kill him before he could harm their leader. He tried to gather his nerve for the assault, pushing away the fears that gripped him like chains.

Then the screech of a new voice from the outer chamber split the air.

"Stay your hands," the Professor translated.

Shorty and his cohort spun their heads as one towards the newcomer. They pushed one another aside to clear a passage.

Eight more red monkeys filed into Jerome's room, led by one dressed in white gauze and wearing a headdress of gilded leaves and berries.

"Grandmother!" Shorty cried.

"Put your weapons away," Grandmother ordered. "Let no harm come to the angel or his assistants, and do no damage to his equipment, or your lives will be forfeit on the instant."

"Yes, Grandmother," Shorty said, as he bowed his head towards her. His militia retreated slowly from the doorway, and Shorty himself sagged into a pillow near the window.

Shorty's grandmother stepped closer to Jerome and looked him up and down. Her fur was gray at the edges, and a fine network of wrinkles webbed their way around her eyes. She licked her lips with a thin pink tongue.

"You are quite large," she said after a moment. "I wasn't told that you would be so big."

"I'd apologize for that if I thought it was my fault," Jerome said.

When the Professor translated, she spun her head in its direction, then chittered in amusement. "Your machines are as clever as you are," she said.

"Thank you," Jerome replied. "I think."

"I am the Dame Rip-yap-ko, and my will now prevails over all of the Palace of Burning Rabbits. You may put your fears at ease. No harm will come to you now. Things have changed for the red

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monkeys."

"Changed? How?"

"We are back in control," the Rip-yap-ko said. "The males have done all the damage that could be allowed. The females have returned to power."

"Returned?"

"Yes, returned. For all our exile in Suridash, until only recently, the red monkeys were a matriarchy. How else do you think we survived for so many generations so far from home? We have only allowed the males to rule for a short time. It was necessary. Their ideas seemed to have merit. Your work has shown that some of those ideas were worthy of wisdom. But we have allowed them enough freedom—and it has cost us enough blood and seed."

Jerome thought about it. It slowly came to him that he had been successful beyond his imagination. He was sure that if he drew Shorty into an error of judgement it would bring an end to his ordeal, but he had never considered in detail what would follow. He had assumed that he wouldn't survive long enough to worry about it.

"And what will happen to me?" he asked at last, fearful of what Rip-yap-ko would answer.

"You will be returned to your tribe," she said. "Your assistant will be freed. Your equipment will be returned to you. We will keep the pups that you created, however. They will be useful to us when they are grown."

"I'm sure they will be," Jerome said. "But by then, I hope to be far away from Chamal and the Rift Valley and the Red Monkey and all your schemes and plans and desires."

"Perhaps you will be," Rip-yap-ko said. "But you will be forever a part of the history and the destiny of the Red Monkey. And the Red Monkey will forever be a part of yours."

Then the giddiness of his sudden salvation overcame him and he began to laugh. He continued for several minutes, until his heart pounded and his face grew warm and his breath grew short, for he saw what the future held for him.

His work would not go unchallenged. Back on Earth, researchers would question his findings and great textwars would rage across the nets, with him at their center. He faced many years of struggle to establish the truth of his vision, but none of it would compare to what he had been through here on Chamal. His long ordeal would be the proof of his sincerity, and the red monkey matriarchy that he had created would be the proof of his discovery. He understood, in a sudden flash of insight, that they were linked in ways that could never be undone.

And that set him laughing once again, until Rip-yap-ko retreated and the Professor offered weak apologies for Jerome's uncontrolled hilarity.

It took Yulish eight days to arrange things with the red monkey matriarchs in Suridash, but in the end, she was able to return to the enclave, this time as an honored and respected guest. The Seedkeepers were going to make her a wise teacher of the wise, but her status with the red monkeys relied on more than that. She held secrets that were of unnumerable value—all that the angel Jerome Sullivan had taught her about chamalian genetics—and her wiser voice told her that she had much work to do.

She was escorted into the cool depths of the red monkey enclave, past overmasters and firecats and armed guards, through long corridors lined with tapestries of red monkey conquests, and into the great hall, where eight aging females sat in eight carved wooden chairs under a canopy of pink gauze.

She never flinched or trembled. She was confident of the sanctuary promised her. The Seedkeepers were always welcome to come and go on their business with the red monkeys. She

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never once touched the charm bag that she wore on her belt.

Her request was simple. She wanted one of the red monkeys' slaves.

"His name is Yap-chorl, and I need his knowledge to complete my work," she explained. "Give him to me, and the rewards will be worth the Sun and the moons and all the stars."

The red monkey grand-dames chattered among themselves for a long time, then made an offer of terms—shares of future incomes and power over future secrets. She bickered and bartered until both she and the matriarchs were sure that they had the best deal.

Servants brought a cushion for her to sit on while they fetched Yap-chorl and offered her sweet tea and fried pastries to enjoy during the wait. Then the doors swung open and the guards escorted a puffy-cheeked rodent with a long fluffy tail and long delicate fingers into the chamber. The red monkey matriarchs rose as a group and filed out of the hall.

"Do not disappoint us, youngling," the senior matriarch said as she headed out the door.

And when those doors closed behind them, Yulish turned to Yap-chorl and said: "I trust you haven't forgotten how to make a microforge. If not, then we have a lot of work to do. First, we will need petri dishes. Lots of petri dishes. And a sterile work environment . . ." ■

(EDITOR'S NOTE: "Seed of Destiny" takes place on the same world as "Seed of Reason," in our April 1999 issue.)

IN TIMES TO COME

Our February issue starts a new serial unlike any you've read before. *Shootout at the Nokai Corral* is Rajnar Vajra's first novel, and the title and opening scene may make you wonder whether it somehow sneaked into the wrong kind of magazine—though Kelly Freas's cover will tip you off that it isn't *quite* what it seems. Vajra does have a lot of fun (and so will you!) putting highly original twists on clichés of at least two genres, but he also has quite a tale to tell, and it's quite solidly science fiction. There's a reason why this world looks so familiar, and yet so strange; and you'll find it full of the challenging ideas, lively action, startling zigs and zags, and engaging characters you've come to expect from Rajnar Vajra.

Richard A. Lovett returns with a science fact article on "Paleolakes, Jökulhlaups, and Mobergs: What Iceland Reveals About 'Wet Mars.' And we'll have stories by Maya Kaathryn Bohnhoff, Stephen L. Burns, Brian Plante, and Wolf Read, at least some of which could be considered "seasonally appropriate." Just how many depends on you interpret that phrase and how you count, and I can tell you no more than that!

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SCIENCE FACT

Kepler Mission: Discovering Earth-like Planets

Yoji Kondo

Introduction:

The Kepler Mission is designed to detect Earth-like planets in our galaxy. In December 2001, NASA approved Kepler for launch into an Earth-following orbit in 2007. This satellite observatory will search for planets similar to ours in the Cygnus region of the sky, an area of about 105 square degrees. For comparison, the Moon's diameter as seen from Earth is half a degree. Kepler will monitor this section of the sky continuously for four to five years to observe repeated planetary occultations of some 100,000 stars like our Sun.

Detecting Earth-like planets has several important consequences. At the moment, we do not know how frequent the formations of planetary systems containing planets like Earth are. In order to understand the origin of our Solar System, it will help immensely to know if ours is unique in the Galaxy—although current theories of solar system cosmogony suggest that a planetary system like ours should not be unique in the Universe. If there are other Earth-like planets orbiting their suns, similar to ours, at a distance like that of Earth, i.e., one astronomical unit, there would be reasonable chances that life might have evolved elsewhere in the Universe.

Our Sun has a surface temperature around 5600 degrees Kelvin, with a radius about 100 times that of our planet. Its mass is a little over 300,000 times that of Earth. It is called a dwarf star as, being only about 4.5 billion years old, it has not yet evolved sufficiently to become larger in size; in some billions of years hence it would eventually become a giant star a few tens of times bigger than it is now. A long time before that happens, Earth would cease to be a good place to live.

Since we only know about one sort of life, we can talk realistically about our kind of life rather than other exotic

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Portrait of Johannes Kepler
Figure 1 courtesy of Sternwarte Kremsmünster

forms, such as silicon (instead of carbon) based life forms, that are speculated about in science fiction tales from time to time. Observational data on the frequency of Earth-like planets are an essential term in the equation used to calculate the frequency of extraterrestrial intelligence but are sadly lacking. At the moment, we know of only one planet that fits the requirements—Earth. Hence, the importance of finding Earth-like planets in search of extraterrestrial intelligence or ETIs.

Even if we fail to find ETIs elsewhere, wouldn't it be good to know that there are Earth-like planets in our Galaxy to which we can all move before our solar system ceases to be hospitable to the human race as the Sun eventually turns into a giant star?

Before discussing how the Kepler mission differs from other ongoing efforts to detect extra-solar-system planets, let us first examine astronomical techniques used currently to detect extrasolar-system planets, and why using these methods will lead mostly to the detection of massive planets like Jupiter—but not lightweight planets like ours.

Planet Detection Techniques Currently in Use:

The presence of a planet orbiting around a star—not necessarily a sunlike star—is presently detected by observing the Doppler shifts that the less massive planetary companion causes in the spectrum of its primary star. Thus, the detection is basically limited to massive planets only, as just massive planets could cause observable Doppler shifts in the spectra of their primary stars.

Discoveries of some 80 planets have been reported over the past decade or so, but those were mostly giant planets like Jupiter or even larger. A few of them might even be brown dwarf stars, especially since the method of detection used typically yields only the lower limits of the masses of orbiting bodies

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around those stars. A few of them are asteroid-sized objects orbiting around a pulsating neutron star which does not provide hospitable environment to life forms like ours. They have been detected through the Doppler shifting of the pulsar's radio signals.

For the latest edition of "Extra-solar Planets Catalog," the reader may visit the website for Kepler <www.kepler.arc.nasa.gov> and check out "Links to Other Sites on Planet Detection," or go directly to <http://www.os pm.fr/planets>.

These discoveries have been based on the movements of the suns of those planets around the common centers of mass. The (minuscule) motions of those stars are in proportion to the relative masses of the planets and their distances. If the mass of a planet is one thousandth that of the star, the star's motion would be only one thousandth that of the planet. The closer the companion planet is to the star, the greater the Doppler velocity of the star. This tends to favor the detection of a massive—at least Jupiter-sized—planet orbiting close to its sun. This is reflected in the catalog of detected planets using the spectroscopic method.

It should be noted that we observe only the line-of-sight component of the velocity of the star involved. That component depends on the inclination of the planetary orbit. By custom and tradition, the orbital inclination is defined as the angle between the plane of the sky (i.e., the plane perpendicular to the line of sight) and the planet's orbital plane. The orbital velocity of the star observed by us from Doppler shifting is "the actual orbital velocity (space velocity) of the star multiplied by the sine of the orbital inclination." So, we can only observe the minimum value of the orbital velocity, unless we can also determine the orbital inclination—for example, by observing the transit of the secondary body.

If a putative planet with one thousandth the mass of the Sun—i.e., approximately the mass of Jupiter—is orbiting around a star like our sun at roughly the distance of our Jupiter, its line of sight maximum Doppler velocity is a thousandth of the mean orbital velocity of Jupiter (about 13 km/s) times the sine of its orbital inclination to the plane of the sky. If the orbit should be in the line of sight (an optimum case for detection as the sine of ninety degrees is unity), the maximum[1] observed Doppler velocity of that star would be 0.013 km per second or 13 meters per second.

As a fraction of the speed of light, the Doppler shifting would be 13 m/s (the maximum radial velocity of the star) divided by 3×10^8 m/s (the velocity of light), which would come to approximately one part in 4×10^8. For detecting it in the visible light spectrum—i.e., at wavelengths around 5,000 ångstroms (1 ångstrom is 10^{-8} cm)—it would mean observing the shifting of spectral lines in the range of 2×10^{-4} ångstrom or 0.0002 ångstrom. Even if that massive planet were orbiting five times closer than Jupiter from our Sun (one astronomical unit instead of five a.u.), the maximum Doppler shift in the stellar spectrum would be 0.001 Å, for an optimum orbital inclination of 90 degrees.

The team headed by Alan Marcy, who is now at the University of California Berkeley Campus, used what they called "cross-correlation spectroscopy" to achieve the necessary precision in measuring the minute Doppler shifting. In this approach, a large number of spectral features are correlated to achieve the required accuracy. Even using this novel method, it is very difficult to detect Doppler motions less than several

[1] The maximum Doppler shifting is achieved twice during an orbital cycle when the companion is either moving directly away, or toward, the observer.

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meters in the stellar spectrum. The difficulty arises in part from the fact that spectral line profiles do not exhibit perfectly symmetric geometric shapes; they are affected by various gaseous motions within the stellar atmospheres and are also distorted by instrumental effects. Therein lies a limit that makes it impractical to use this technique to detect an Earth-sized planet, whose mass would be roughly one three-hundredth the mass of Jupiter. An Earth-sized planet orbiting around its sun at one astronomical unit—which is the mean orbital radius of our planetary orbit about the Sun—would produce a maximum Doppler velocity of some 10 centimeters per second or about one three hundredth of the quantity mentioned in the last example—about 0.00003 Å—even if the orbit were exactly in the line-of-sight. It is well beyond the capability of present spectroscopic method to observe such minute variations.

That is, unless "planetary" motions are detected in the shifting of the frequencies of the radio signals from a pulsar (a neutron star). Such a detection has been reported for asteroid-sized bodies orbiting a pulsar. However, neutron stars do not provide an environment hospitable to life as we know it. Even if an Earth-like planet had existed in a stellar system before the primary star exploded violently as a Type II supernova to form the neutron star, that planet would have been rendered unsuitable for (at least most forms of) life even if the planet had not been ejected from the system in the catastrophic event. With my sincere apologies to Robert Forward and his delightful tales of life in the vicinity of a neutron star, we are excluding neutron stars in our search for Earth-like planets.

Kepler Mission:

Scientific Concept of the Kepler Mission:

If it is all but impossible to detect an Earth-like planet using the current method of looking for the Doppler shift in the spectrum of the primary star, how does the Kepler Mission then detect Earth-like planets?

The Kepler satellite will detect Earth-like planets that are substantially less massive than the Jupiter-sized ones detected thus far by observing the occultations (eclipses) of Sun-like stars, i.e., the transits of their planetary companions. That too is not an easy task, but it is one that can now be accomplished as described below.

The Kepler observatory will continuously monitor the light from about 100,000 Sun-like stars to detect transits of planets. The radius of Earth is one hundredth that of the Sun; therefore, the area subtended by an Earth-like planet is one ten-thousandth the area of a Sun-like star that it may occult during its transit. That will decrease the light from the star by one ten-thousandth. Such an eclipse is expected to last typically half a day to a couple of days, assuming that the planet orbits its primary star at a distance in the neighborhood of one astronomical unit (about 150 million kilometers).

Several factors will influence the detections of planetary companions. In assessing the chances of success, we assume that the orbital planes of planetary orbits are random. That is, although within a given solar system, the planes of planetary orbits may stay fairly close to each other—as is the case in our Solar System—the orbital plane for any given solar system is randomly distributed in regard to the line of sight.

First, the closer the planet orbits around its sun, the higher the chance for its detection becomes, as the allowable range of orbital inclination becomes greater, improving the chance of observing the planetary occultation. Second, the larger the planet is the better the chance of detection.

In order to report a confirmed detection of an Earth-like planet, we must have three consecutive observations of the same planetary transit during the four years of the Kepler mission. If the orbital period is about a year, we should

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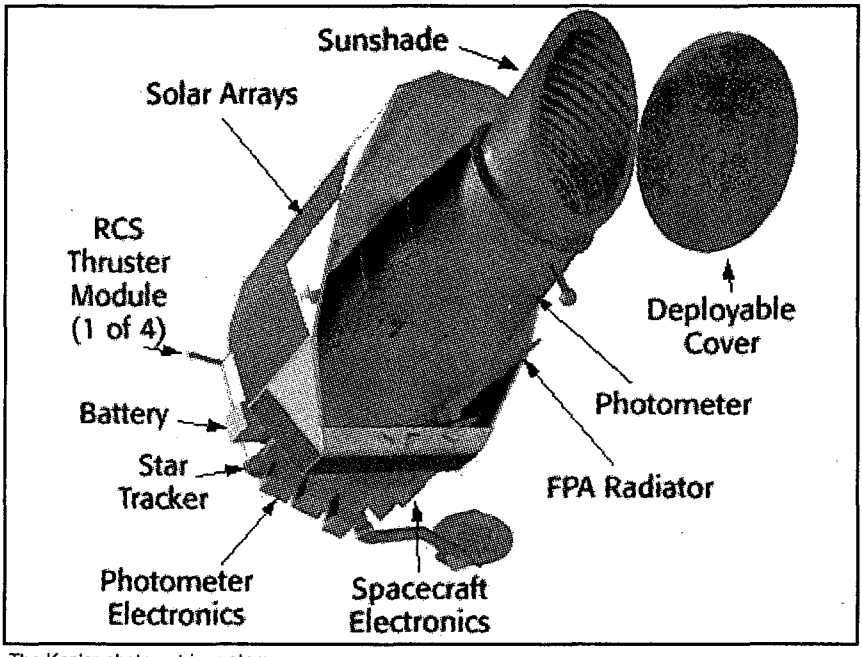

The Kepler photometric system
Figure 2 courtesy of Ball Aerospace

be able to observe the transits three times in four years. In order for the detection to be confirmed, the eclipses must occur at exactly the same interval—i.e., the same orbital period—and the shape and depth of the eclipses should be the same. Those stringent requirements for a confirmed detection would make the Kepler results quite reliable.

If our current understanding of the formation of planetary systems is reasonably accurate, we expect to detect, by monitoring 100,000 Sun-like stars during the four years of the Kepler operation, the following numbers of planets. We assume here that most stars like our Sun have terrestrial planets and on average two Earth-sized planets form in or near the habitable zone, i.e., orbital radius greater than that of Venus (0.7 astronomical unit) but smaller than that of Mars (1.5 astronomical units).

- About 50 planets if most have 1.0 Earth radius (with the presumed mass around 1.0 Earth mass);
- About 185 planets if most have 1.3 Earth radii (with the presumed mass around 2.2 Earth masses);
- About 640 planets if most have 2.2 Earth radii (with the presumed mass around 10 Earth masses).

Actual planetary systems are likely to be some combination of the above. In coming up with the numbers above, it is also assumed that in about 12 percent of the cases there are two or more planets per system.

Based on the more than several dozen giant planets already found outside the solar system, we expect to find:

- About 30 outer (giant) planets;
- About 135 (giant) planets with orbits from four days to one year like those already found.

You might be thinking that, if the Ke-

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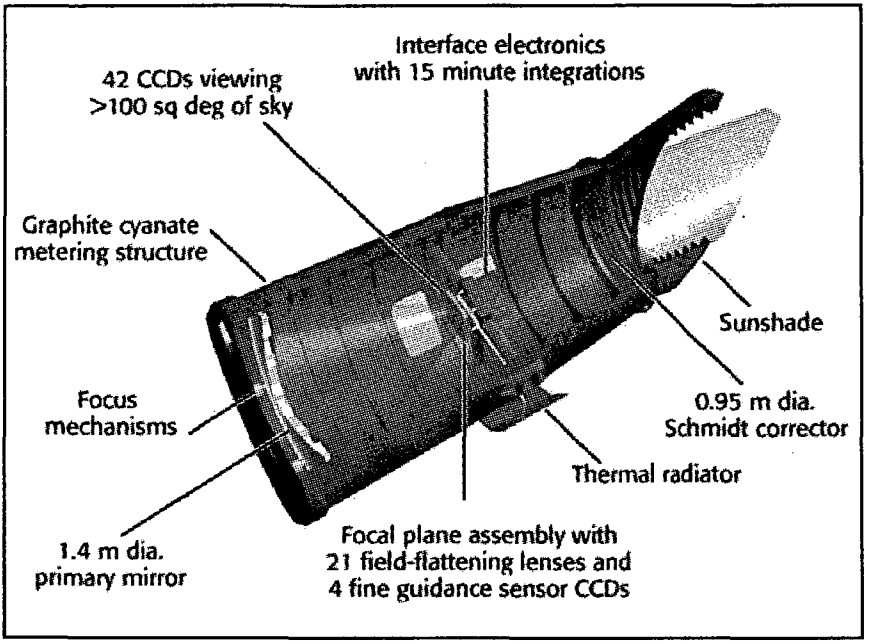

The Kepler spacecraft assembly
Figure 3 courtesy of Ball Aerospace

pler observatory is going to monitor many thousands of stars continuously for four years, it would be an excellent facility for studying variable stars in that region of the sky. Indeed, the Kepler mission has a guest observer program, which will provide an opportunity to investigate all sorts of variable objects, such as eclipsing binaries, cataclysmic variables, X-ray binaries, microvariabilities in Sun-like stars, and so forth. The opportunity to propose is open to the entire world; all submitted proposals will be refereed by competent professional peers.

Orbiting Kepler Observatory Hardware:

The Kepler observatory will be placed in an Earth-trailing, heliocentric orbit in 2007 for a four-to-five-year mission. In such an orbit, the satellite will not go in and out of the shadow of Earth, thus avoiding temperature variations in the sensitive optical and detector systems. The optics consist of a 1.4-meter-diameter primary mirror with a 0.95-meter aperture Schmidt-type corrector. The sensors are CCDs (charged couple detectors). An array of 42 CCDs is sampled every three seconds; the data are transmitted to the ground typically at an integration interval of one to fifteen minutes. A ground-based version of this telescope is being tested at the Lick Observatory on Mt. Hamilton in California.

Further efforts in search of extra-solar-system planets:

Follow-ons to Kepler could be telescopes to image individual planets in nearby solar systems. To avoid atmospheric blurring of the planetary images, those telescopes will probably be operated in the vacuum of space, possibly from the Moon in some instances. For an array of interferometric telescopes, the Moon would serve as an immense optical bench in vacuum. The following two types might be considered; both

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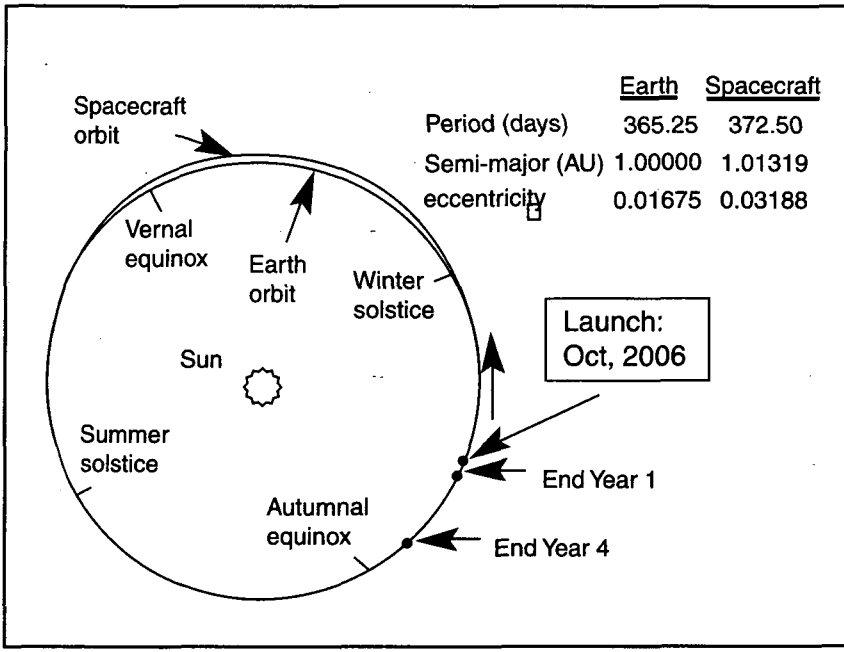

The Kepler satellite will be launched using a Delta II rocket in an Earth-trailing, heliocentric orbit
Figure 4 courtesy of NASA Ames Research Center

types of technologies are being developed and tested.

(A) Apodized mirrors that can modify the shape of the diffraction pattern of a bright source (such as a star) to facilitate the detection of a faint nearby object (such as a planet); often an apodized mirror (in square shape, for example) can produce a diffraction pattern in the form of a cross (rather than classic diffraction rings), thereby making it easier to detect a faint planetary object close to the star. Apodized mirrors—being designed for use in the vacuum of space—can reduce the light from the primary star by as much as 10^9. With such a mirror, one could take an image of an Earth-like planet, up to a distance of several parsecs, by looking at its atmospheric oxygen line, when the angular separation from its sun is equivalent to one astronomical unit.

(B) Arrays of interferometric telescopes, utilizing apodized mirrors, that can resolve individual planets.

Considering the low surface temperatures of the planets to be imaged, those telescopes would probably work best in the infrared.

The significance of the results from Kepler:

If the current theoretical models for the formation of solar systems are correct, Earth-like planets—for that matter, planetary systems—should be fairly common around stars like our Sun. Detections of Earth-like planets should serve to verify the prevailing cosmogony or the theories about the formation of the solar system.

If, on the other hand, no Earth-like planet outside the Solar System is found by the Kepler mission—when several dozen detections are expected—it means that our Solar System is unique in our Galaxy, quite possibly in the Universe itself. In such an event, the very concept of the Search for Extraterrestrial Intelligence (SETI) program would need

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to be reexamined. The SETI program is based on the assumption that Earth-like-planets, which are hospitable to advanced forms of life, are fairly common in the Universe.

The philosophical implications of learning that a planetary system like ours may be rare, if not unique, in the Universe would be momentous—regardless of its implications for the SETI program.

Points of special interest to science fiction writers and fans:

The results from the Kepler satellite could have important bearings on the nature of science fiction stories of the future—particularly where the stories involve the exploration of extra-solar-system planets beyond the Edgeworth-Kuiper Belt. Besides, wouldn't you say that, a few centuries from now, it would be nice for Captain Kirk to know which way to take the Enterprise on its five-year mission?

Some additional information about the Kepler Mission:

William Borucki of NASA Ames Research Center is the principal investigator for the Kepler mission; the Kepler team involves 25 scientists from 16 different research institutions. For more information on the Kepler mission, the interested reader is cordially invited to visit <www.kepler.arc.nasa.gov>.■

About the author:

Yoji Kondo is a coinvestigator on the Kepler project. He has authored or coauthored, under the pseudonym of Eric Kotani, two short stories and seven books in science fiction, the latest of which is *Legacy of Prometheus* with John Maddox Roberts. He also edited, under his real name, *Requiem: New Collected Works by Robert A. Heinlein and Tributes to the Grand Master*. Recently, an asteroid (#8072) was named Yojikondo in recognition of his contributions to astrophysics and the space program.

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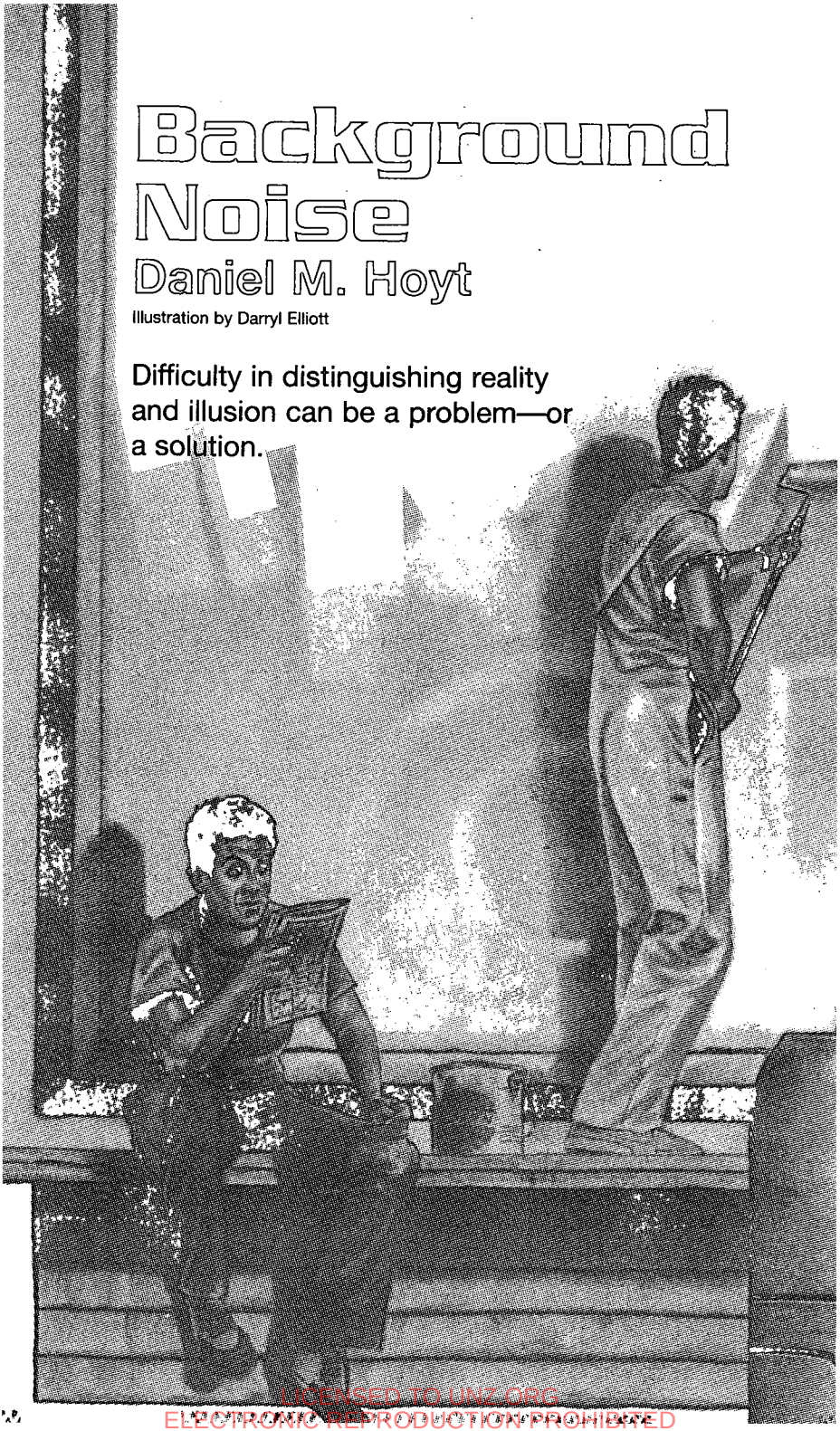
Background Noise

Daniel M. Hoyt

Illustration by Darryl Elliott

Difficulty in distinguishing reality and illusion can be a problem—or a solution.



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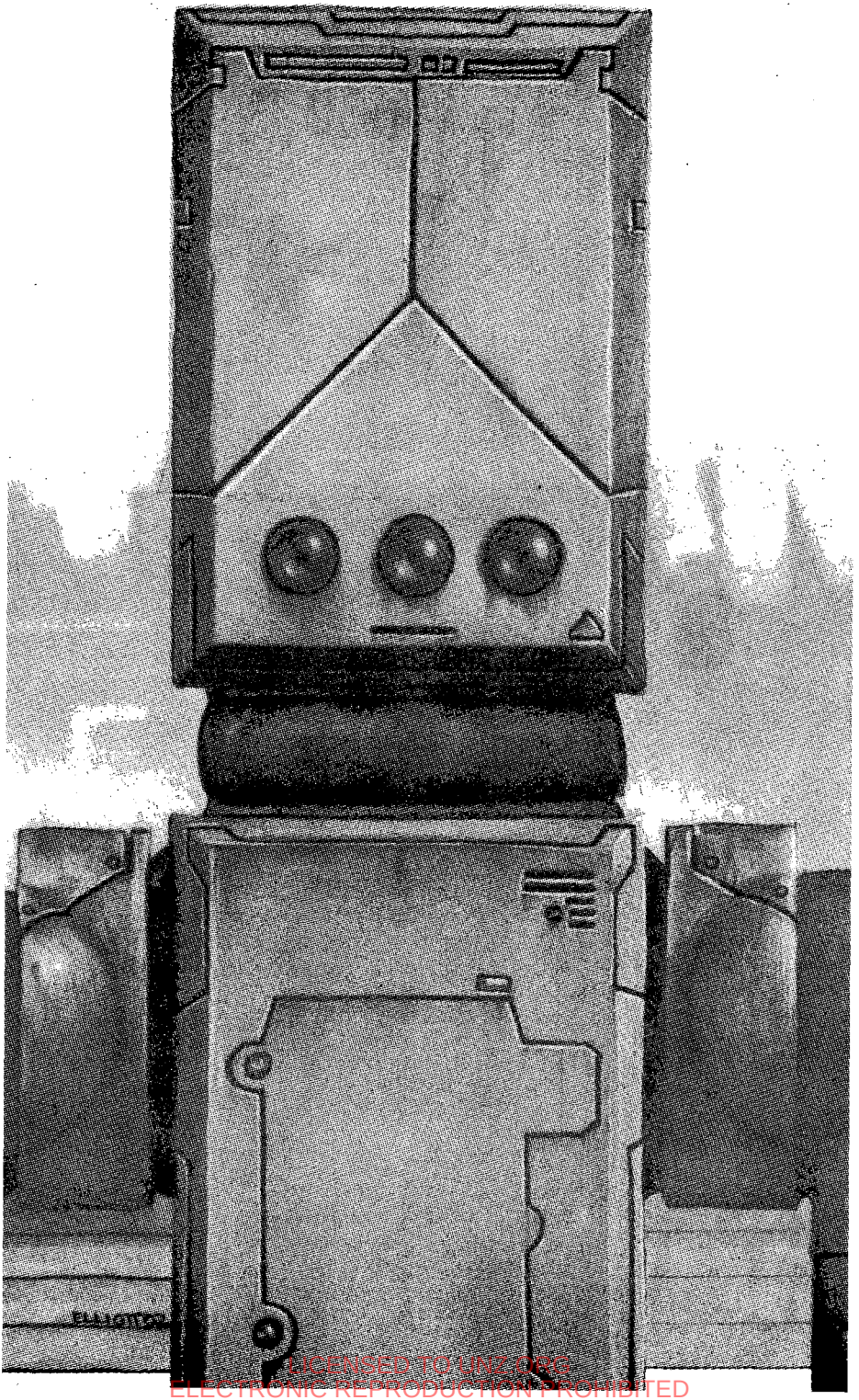

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Once, a man loved a woman . . .

. . . but what if she weren't really a woman?

Someone once told me you had to learn to love yourself before you could love someone else. That we all had basically the same desires and needs and you had to understand them in yourself before you could deal with them effectively in others.

Well, I missed that class on understanding myself, but I was okay. I still grew into a perfectly healthy, normal twenty-something American guy in love with a perfectly healthy, normal twenty-something American girl.

Or at least I thought she was. Rachel, I mean.

But she wasn't. And I'd really *believed* I loved her. Which was impossible, of course, because she wasn't real. So her desires and needs couldn't possibly have been the same as mine; it *couldn't* have been love. Could it?

It was all very confusing.

Which was why I found myself sitting up on the scaffolding below a billboard, three stories high, legs dangling off the edge, pretending to read an old-style paper comic book, but actually trying to think of a good reason not to plunge off. Of course, I came up with one reason right off the bat: jumping from only three stories probably would break my legs, but might not actually kill me—why bother? But a good swan dive would solve that problem, so I was still thinking, staring at Dogies from three stories up, trying to wrap my mind around Rachel.

Rachel waited tables at Dogies. The place was practically invisible, wedged between a rib house and a bar, east of downtown Denver on Colfax, past the Greek diner that had been there *forever*, but before the block of thrift stores. You probably passed it a million times without even noticing it.

I bet you saw the Diver, though. It was one of the first of those holographic billboards that you see everywhere now. One of the first batch was right here, next to Dogies—okay, it wasn't Dogies back then in 2017, but the billboard was right there where Dogies is now. Remember the Diver? The Mexican travel authority did those cliff diver billboards all around the States, a blatant grab for the almighty tourist dollar. There was a trim, muscular guy in a teensy little swimsuit standing dead still on a rocky outcrop, all of it framed by a flawless blue sky. Then the guy stepped right *out* of the middle of the billboard—as if it had been a *real* person that was just standing there, instead of a painting—and leapt, in a perfect swan dive, splashing into a little pond on the ground beneath the billboard.

It looked almost real, like some guy who was trying to commit suicide. Almost, but not quite. If you paid attention, you'd notice that the pond wasn't there until the Diver jumped, and then it'd evaporate after the Diver disappeared beneath its phantom surface.

Nobody had seen billboards like *that* before. Within hours, they were the talk of the towns that were lucky enough to get one. In days, they were a certified hit for Mexican tourism.

Sure, there were some rubberneckers and traffic jams for a few days. But people got used to new things pretty quickly.

Denver was different. Space was tight, and the Diver billboard went up right next to the road. That pond wasn't five feet from the lanes. All of which was okay, except that the Streets Department was planning on widening that same stretch of road during the next month.

The Mexicans never checked with the Streets.

The Diver kept diving even while they were working on the road. The Streets crew joked about it when the Diver melted into the wet asphalt, but they ignored it and kept on working.

Apparently, none of those idiots thought—and I don't mean just the

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Streets crew, but City Hall and everybody else who should have known better—nobody thought, *Gosh, won't that Diver come down right in the middle of the new lane?*

Guess what happened?

Yep. Some poor sap from Nebraska was driving along in the brand-spanking-new right-hand lane, calm as you please, taking in the sights of the big city. And then, out of nowhere, a mostly naked guy went *splat* in the middle of the road directly in front of him.

Well, the tourist freaked. Wouldn't you? He screeched to a halt; someone else plowed into him from behind and catapulted him into the next lane. And then someone else hit *both* of them in succession, glancing off one and smacking the other square in the tail. The chain reaction sent the poor Nebraskan tourist spinning right into oncoming traffic. And so on, and so on.

There was a forty-car pile-up when the smoke cleared.

Denver eventually accepted financial responsibility—after a particularly nasty fight with the Mexican authorities—and made a few out-of-court settlements with some of the drivers and, of course, the Nebraskan's heirs. And they fired the entire Streets crew once it came out that they knew about the Diver's destination in the middle of the lane and just laughed it off without telling anyone.

The Diver's still up there now, five years later.

After that unfortunate incident with the Nebraskan tourist, the Streets made the Mexicans change it so that the Diver went down in the alley, instead of the middle of the traffic stream.

Of course, you hardly notice it any more, what with all the other stuff assaulting your eyes. There was the Skateboarder who jumped over the road and landed in the parking lot across from Dogies—the lot with the big holographic house; there was the sprint car Racer with some pretty powerful artificial intelligence that somehow managed to appear in the space *between* cars—yeah, right in the middle of moving traffic—then turned, smiled and waved at the poor, surprised blighter driving next to him before turning off onto a holographic dirt road leading up into the sky toward a holographic Pikes Peak.

And the show kept going all the time, day and night, like another world in the background. . . .

I remember the first time I went into Dogies, about four years ago. I was new in town, looking for a nice homey kind of place for lunch. But I'd heard about the Diver—my native Wyoming didn't rate a single Diver—and I went off looking for the classic Diver billboard instead. I figured, *Hey, it's just before noon; there's plenty of time.* I mean, I'd found Colfax easily enough; how far down the road could it be?

Nobody told me Colfax was so damn *long.*

Eventually I found it, midafternoon, when I was just about to give up plodding along the endless street on this fool's errand. I saw the Diver go down from a few blocks away, and I got so excited that I sprinted the rest of the way, despite my aching feet. I skidded to a halt in the alley and the Diver came down right in front of me.

I just stared at the show for a few cycles, mesmerized with the novelty. The only holographic billboards that made it to the little backwater Wyoming town I grew up in tended toward simple animations locked within the boundaries of the billboard, like silly used-car salesmen poking their annoying heads out of the billboard at you.

My growling stomach broke the spell, and when I tore my gaze away, I found myself staring blankly at—Dogies. Not only did the place claim to specialize in good old Colorado-grown cow burgers, they were still open for lunch, even though it was nearing dinner time.

"New around here?" the waitress asked me while pouring some steaming black coffee into a chipped mug.

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I looked up into the purest blue eyes I'd ever seen, set against flawless alabaster skin and the highest cheekbones I could hope to find, all of this perfection framed by a fiery glow of medium-length red hair.

It was that moment I knew I was in love.

I stared at her, dumbstruck.

"Nice shirt," she said, tipping the coffeepot toward me and nodding at my chest. "You know what you want, sugar, or do you need a minute?"

Wyoming? Why not? That's what my T-shirt read, just below a big graphic of the X-Men and above last year's National Comics Convention logo, held in—you guessed it—scenic Wyoming. Blushing slightly, I made a mental note to get a more nondescript T-shirt after lunch-dinner. Even *I* didn't consider Wyoming a tourist spot worthy of bragging around here. And I really didn't want to start off any future interviews I'd manage to win by giving my prospective employers erroneous preconceived notions about my grip on reality.

When you are an adult who collects comic books—the old paper ones, not the new plastic, guaranteed-to-last-forever ones—you don't wear a Superman cape if you want other people to take you seriously. Actually, I never wore the cape *anywhere* besides a comics convention, but the Wyoming NCC T-shirt wasn't much better. In most people's minds, it identified me as some kind of freak who never outgrew his geeky adolescence. What an impression for this gorgeous waitress.

Before I had managed to regain my power of speech, Rachel smiled and walked away, her heels clicking in time with my heart beating in my throat.

I'd never even had a girlfriend before—having decided in my geeky preadolescence that no girl would ever want both me *and* my comics—and there I was falling all over myself for a waitress. Right. The last time *she* probably had seen a comic book was in the hands of an eight-year-old ordering a kid's burger and Dogies' trademark cow-shaped fries.

Maybe I didn't have many friends, but that was okay with me. I always made a few in whatever places I drifted to. Jobs changed, you moved from one house to another—none of that mattered in the long run. *Relationships* mattered, although I didn't have many of those, either. Okay, I didn't have *any* relationships right then, being new in town.

But just for a second, when I first saw Rachel, I thought I'd found someone who mattered, someone I could develop a *real* relationship with, a relationship deeper than any I'd ever had before. In that moment—despite the deep-seated knowledge that I was certainly unworthy of someone like her—I set off on a journey to win her heart.

Had I succeeded? Actually, four years later, I still didn't know.

I became a regular at Dogies. I knew Rachel's schedule by heart. She knew all about me and sometimes even asked after my kid sister, who was trying to make it as an actress. But four years of intimate conversation later, I'd never worked up enough nerve to ask her out. Maybe I was too shy, maybe I was just stupid; I don't know, but I'd never asked her out. Instead, I kept coming back, week after week, like a pitiful junkie, desperate for my Rachel fix.

And she still looked as stunning as the first day I laid eyes on her.

Until today. I went into Dogies for my usual Wednesday lunch with a new old-fashioned paper comic I'd picked up the night before, and glanced around for my beloved.

She wasn't there. In fact, none of the other waitresses were there, either. There were these *things* there instead, kind of like miniature siege towers, moving from table to table on little square bases with a bizarre arrangement of wheels that let them move in any direction without twisting around.

One of the towers rolled over to me

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while I waited at the door. And I swear that Rachel's voice came out of it.

"Hi, Angus. Your usual today?"

It took my shocked silence for a *yes* and rolled away, heading toward one of the tables facing the street—my favorite spot.

I recovered from the shock about the same time *it* reached my table and stopped, waiting for me. Slowly, I shuffled over there, eyeing the tower warily.

"Do I know you? How'd you know my name?"

"Angus, you okay? You been coming in here for years."

I searched the tower for some kind of face, but there was nothing, no human reference to fix on. I squinted at it, hoping Rachel would magically appear in the blur from my crossed eyes. "What *are* you?"

The tower laughed. It was actually a bit disconcerting the way it did that, with no face or mouth or anything. Okay, it was downright spooky. How can a siege tower laugh?

"Rachel, silly," it said. "Don't you recognize me?"

It sure *sounded* like Rachel, but that was impossible. Rachel was a *woman*, not a siege tower on wheels. She—*it*—went off to get my usual jack and bacon burger with chili fries and a beer. I just stared after it.

It didn't turn around, just rolled away in another direction on those omnidirectional wheels. Weird.

About that time, some guy in a shirt and tie came out of a nondescript room in the back, followed by a funny-looking guy in a cowboy hat that I thought I recognized. Rachel had told me once that the cowboy was the owner. The two of them walked by my table, talking low, but I caught part of their conversation.

"—booting now. Should be back up in a second, and the holograms will automatically start. I just want to verif—"

The tower rolled back over to me, two little shelves sticking out from it like arms, my burger and fries on one shelf, the beer on the other. About a foot away from my table, this weird electrical sizzle surrounded the tower and a bright blue flash blinded me.

Instinctively, I squeezed my eyes shut and looked away, hoping for some protection from the bright light, but I still saw spots when I opened my eyes again.

The siege tower was gone.

Rachel was there, placing my order on the table in front of me like always, burger and beer to the right of my open comic book. She smiled at me. "Anything else today, Angus?"

I swallowed hard and shook my head slowly. I stared at her slack-jawed as she turned and left. Behind Rachel, the cowboy owner, looking pleased, smiled and shook hands with the technician, who gave the cowboy an invoice and left.

I looked back at the retreating waitress and swallowed again, my mouth suddenly very dry. I felt weird—as if squinting and looking at her slanted, I'd somehow be able to see the siege tower underneath, rolling along blindly, not even bothering to twist when Rachel turned in another direction.

The reality hit me hard in the pit of my stomach. Rachel was just a hologram, like the Diver. A fantasy, an illusion—just a cost cutter so the diner didn't have pay humans.

And I was in love with her. It.

It was embarrassing, frankly. I bet I was the only one there who had thought she was a real human.

That burger tasted wrong somehow, like a last meal. I wondered if maybe someone up there was trying to tell me something. . . .

I left Dogies, dazed.

Rachel wasn't just a girl I was in love with. She was the *only* girl I'd ever been in love with in my twenty-eight years. And she wasn't even real. How many times had the other diners noticed my puppy-dog infatuation with the redheaded hologram and laughed at me behind my back?

My life was a joke.

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So I climbed up on that billboard, clutching my comic book for some kind of reassurance that my world was still okay.

Why that billboard? I didn't know.

Maybe it was the scaffolding at the bottom—probably a leftover from when the billboards were paper and paste, not holograms. Or maybe it was the fact that amidst all the flashy holographic experiences, it was static and unchanging. Just the current model of Chevy—or Ford or whatever, as if there were differences any more—painted there alone on the board, doing nothing special.

Like me. Background noise.

Amazing.

I should have known better than to think the Chevy billboard was what it seemed. Nothing around here was.

I had just five minutes alone, contemplating my pathetic existence, before some other idiot climbed up after me. I yelled at him to go away and leave me alone.

He was dressed in painter's coveralls, climbing up calm-as-you-please despite my angry protests and shouting. I almost kicked over one of the buckets of paint from the scaffolding in the hopes of drenching the fool in bright pink.

Funny, I hadn't noticed the paint buckets before.

He climbed up on my scaffolding, adjusted his coveralls and immediately set to work.

"Hey, how you doing?" I asked him, trying to sound annoyed, hoping he'd get the point and leave.

He ignored me and started painting over the car ad.

At least the guy had balls, if not too much smarts. At some point, somebody'd probably notice what he was doing and come after him. The police would probably be here in a matter of minutes. . . .

Which suited me just fine once I thought about it. What's the sense of jumping off a billboard without an audience?

I shrugged and went back to my comic book. Let the crazy fool go about his work while I waited for my audience. I had time to kill.

The painter inched over during the next few minutes until he was standing right next to me. When he'd finished a section only inches away from where I leaned against the billboard, he glanced down at me for a moment, as if he'd never seen me before, then shrugged and painted around and above me. Taking a long step over me, he continued on the other side, leaving a small me-shaped section unpainted.

Never a word. I was just a minor, temporary inconvenience. It was as if he were telling me, "No problem, buddy; I'll just wait until you jump and then come back and do that section."

His attitude steamed me. I decided I'd just take my time about it, then, thank you.

The Skater sailed past a few feet below my scaffolding—after a double flip and twist over the road to a tricky landing in the parking lot below me. The hologram wove around some of the cars in the parking lot and stopped in front of the hologram house. The Skater paused, skateboard tucked under one arm, apparently reading the holographic realty sign stuck in the perfectly green holographic lawn outside the house, then walked up the front walk, opened the front door and disappeared inside.

Had I seen that right? Or was I just hallucinating?

I looked across the road, where the Skater had started its jump from a holographic Skate Park, and it reappeared over there, doing some simple tricks and basic jumps, apparently building up to its spectacular jump over the road.

Glancing back at the parking lot, I noticed the house was gone. There was a billboard above it, with a hologram of the interior view of another house, a smiling realtor beckoning.

This was interesting. I couldn't see a

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good reason for there to be a business relationship between the realtor and the Skate Park, yet I'd *swear* I had witnessed the Skater walking into the holographic house.

Hmm. I didn't know they could see each other. If *see* was even the right word.

The implication was a little scary. Were holographic billboards out here, forming their own interactions, creating their own social structure? Spontaneously? No, that couldn't be right. It was just the artificial intelligences adapting to each other. That's all. Some bright bulbs had programmed them to look for other holograms and adapt. It was no different from what the Racer did, just with other holograms instead of humans.

But it was still unnerving. Hell, I couldn't even manage to hold up my end of a conversation in the real world, but these holograms were interacting with each other, just like real people did.

Now, *that* was depressing. Holograms were better at real life than I was.

Maybe somebody up there *was* trying to tell me something. The one time I had managed to forge what I thought was a relationship with someone—or was Rachel a *something?*—it wasn't in the real world. Maybe I was better suited for the virtual world than the real one....

Geez. What kind of crazy reasoning was I thinking now? Was this whole billboard thing driving me insane?

Just then, the Painter stepped over me, heading for the ladder. Startled, I lurched sideways, upsetting the paint bucket nearest me.

Only I didn't upset it, because it wasn't there any more.

I glanced at the Painter climbing down from the billboard, then stared up at his work. He'd painted over the entire billboard—except for my outline—with the bright pink paint, then hand-painted in fluorescent green a plug for some new brand of house paint.

Staring after the Painter in amazement, I watched him climb down and walk over to—surprise!—a brand new holographic house under the Realtor's billboard. He walked behind the house and came back with an extension ladder, which he used to start painting the second story in the same bright pink paint he'd used on the billboard.

Of course. Why didn't I see this before? The Painter was just a hologram, too. No wonder he'd largely ignored me and just painted around me. I should have realized there was no new-paint smell. Once again, there I was mistaking holograms for reality. I felt like sliding off the scaffolding in shame.

I stared at the Painter for a minute before it hit me what he was doing to the house, then I almost lost my balance from laughing so hard. I wondered what the Realtor would think of the Painter's colorful enhancement to what was obviously a well-cared-for mini-mansion the Realtor hoped to sell for a small fortune.

Screeching tires out in the road caught my ear as the sprint car Racer appeared in a hole between cars and the surprised driver directly behind the Racer stomped on his brakes, smoke billowing from his wheels. Starkly different from the normal cars, which bore a striking resemblance to columns of huge, identical ants making their way to some unknown destination, the incongruous Racer ignored the commotion, waved goodbye to the traffic and veered off suddenly, kicking up dirt as he ascended a holographic road suspended in midair, heading towards a miniature Pikes Peak looming in the distance.

At that moment, a small holographic pond opened up right in front of the Racer and the Diver came down fast, splashing into the pond right in front of the Racer, who slammed to a halt soundlessly amidst a cloud of dust. The Racer got out and helped the Diver out of the pond, then they clasped holographic hands and both of them turned toward the road and raised their arms high, indicating that they were okay.

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Compared to the goings-on with these billboards, my life was incredibly boring. There seemed to be pretty sophisticated artificial intelligences at work here, with complex rules of interaction in this virtual world that all the holograms followed closely, even though they weren't connected together, just able to track what the others were doing visually.

But why? Why would these companies do this? Did they have some complex revenue-sharing contracts that depended on cross-marketing? Or were the programmers just trying to show off? Marketing types were well known for wanting to do cool new things, even when the new technology did absolutely nothing to help sell the product. Was that all it was? Or was it some revolutionary new concept that none of them could pass up?

I realized then that basing interactions on visual inputs was actually a pretty good model for real life. Hmm. Maybe my problem in the real world had been simply that I didn't know the rules for interaction. . . .

From the corner of my eye, I noticed something change. The new House had disappeared from the parking lot. The Painter apparently had been painting it at the time, and the House vanished mid-swipe. The Painter simply shrugged and climbed down from his holographic ladder, which disintegrated behind him as he headed back to my billboard.

Across the street, above Dogies, there were two holographic Cows stacked one on the other, painting a message begging us to eat more chicken. The one on top flailed its front legs, apparently lost its balance, and tumbled off the other. The one on the bottom caught the Cow's rear leg somehow, leaving the top Cow dangling from the billboard, mooing piteously.

After a few seconds, the suspended Cow dropped *into* the roof of Dogies, its silent impact splintering the roof beams. I must have been getting the hang of these bizarre holographic interactions by then, because immediately I suspected it wasn't real. Either what I thought was Dogies was a hologram or it was just a holographic roof overlaying the *real* Dogies or something. But the hole in the roof was a hologram, I was sure of that.

Within the virtual hole in the roof, visible only to someone three stories up—as I was—I saw holographic patrons inside Dogies staring up in surprise at the Cow's remodeling job on the roof.

Rachel was there, inside Dogies.

That was too weird. She was part of *my* world, not this crazy billboard world. Wasn't she?

Or did she belong to both worlds? Wasn't she a hologram?

For a moment—just a moment—before the holographic hole in the roof of Dogies vanished, I swear I saw myself there, too, standing next to Rachel, holding her hand, staring at the Cow on the floor. The image burned in my memory, superimposed with the reality of the untouched roof.

For a moment, I wasn't sure what was real anymore. Was I really in the hologram? How could I be? I was here on the billboard scaffold. But, if it was just an illusion, why would the Cow's artificial intelligence put me in the hologram? Shouldn't it have been able to detect me sitting on the scaffolding? And if it didn't detect me, how would it know what I looked like to put me in the hologram?

I couldn't reason it out.

With my hobby, collecting comic books, vicariously living through someone else's imagination, I'd essentially cast myself out from what I thought was the real world. But then, there I was in the virtual billboard world, holding hands with Rachel.

What right did they have to put me in the hologram? I never gave them my permission to be there. And who exactly was watching me? It made no sense. The hologram could only be seen from several stories up, from the billboards,

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not from the street. It was almost as if it were intended just for me to see. I mean, who else was there on these damned billboards?

The Painter.

Was this scene normally played out for the Painter? Was it just because I was up there now that I showed up in the hologram? Did the Cow's artificial intelligence just pick out whatever spectator was near—me, the Painter, maybe the Realtor or the Skater—and put him in the hologram? Why? Was this the programmer's idea of a joke? Or had the Cow adapted bizarrely beyond the program's intentions?

I was there this time, so I had been the one holding Rachel's hand in the hologram, but what about when I wasn't around? Was it normally the Painter in there, holding hands with Rachel?

Rage overtook me. Blind, jealous rage, at this weird virtual theft of my Rachel. The fact that I hadn't known about it before was irrelevant. Now that I knew, I couldn't just stand by and let her get heisted like this.

The Painter reached the scaffolding at that moment and nodded at me in acknowledgment, apparently not noticing the seething anger I could feel coloring my face.

I rushed him.

I can't explain why I did it, nor what I expected to happen. He was a hologram, right? I *knew* I'd just pass right through him.

But I did it anyway, and the Painter fell off. We never collided, but I somehow managed to *push* him off, my real body and his virtual one coexisting in the same space for a moment before he sailed away.

As I passed *into* him, I came to my senses and managed to stop short before careening off myself. It was an odd thing to do, considering I'd originally come up there for the very purpose of jumping off.

But what happened was that I went into him and stopped, and the Painter fell anyway.

The Skater was zipping past at that moment, too, and the Painter fell onto the Skater. The Painter spun off and slammed noiselessly on the ground; the Skater twisted away and crashed in the parking lot.

People rushed from all around to help him. Several of them pointed at me and yelled obscenities. Others ran over to the fallen Painter.

Panicked, I climbed down as fast as I could. The crowd thickened and they all seemed bloodthirsty to me. Couldn't they tell the difference between reality and holograms? The Painter and the Skater weren't *real*; didn't they *know* that?

I reached the bottom just as someone in the crowd around the Painter tried to help him up. Of course, his hands just went through the Painter.

The Painter looked bewildered. Some people in the crowd glanced over at me for some kind of validation I wasn't about to provide. The Painter stood up and walked over to his billboard, the crowd parting before him as if he had the plague. He paused in front of me and made an obscene gesture. Then he climbed back up his billboard, which once again sported the Chevy ad.

We all looked over at the Skater. He unfolded impossibly unbroken limbs from positions that a real person couldn't have withstood, then got up, dropped his skateboard on the ground, and dusted himself off, a little cloud of dust settling around him sparkling in the sunlight. As the crowd around him backed away in fright, he skated away, disappearing around a corner.

Several people shrugged and the crowd dispersed amidst muttered conversations about the experience. Nobody paid any more attention to me, except for giving me a wide berth, as if I were a hologram myself.

So, it wasn't just me. The holograms seemed real enough to fool other people, too. Maybe it was perfectly normal

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to wonder what was real and what was imaginary, sometimes.

I mean, sure, we all *knew* the holograms weren't *real*, didn't we? They all had some pretty advanced artificial intelligences that allowed them to interact with each other—and us. But deep down, we knew they were just holograms.

But, still, when the illusion was *this* real, maybe for a moment—just a moment—we just weren't sure any more. Heck, the Diver only caused one accident before *everybody* knew about it, and then nobody paid any more attention to the Diver landing in the road. I bet by that time nobody even noticed when they changed the programming to have the Diver land in the alley.

Usually, the holograms acted in a way we expected, and we knew they were holograms. But when they did something different, they weren't background noise any more and that first time we were no longer sure. When they repeated that something different—as inevitably they would, given their programming, which was geared to repetition—they faded into the background once again.

All of this made for a comfortable coexistence with us humans, with a little excitement thrown in every now and then just to break up the monotony. Hell, they probably *programmed* the holograms to do something different once in a while just so we didn't forget about the products they hawked. Advertisements aren't very effective if everybody ignores them.

But the scene that had just played out in front of me *was* a bit eerie. The holograms were, after all, virtual, not real—I knew that. Yet, it was almost as if they had managed to form a little subculture here, as if they thought, somehow, that they were real, too.

My mind recoiled from the twisted logic instantly, but still it was a fascinating possibility. . . .

In a sense, from the perspective of their programming, within the virtual world they were as real to each other as we humans were to ourselves. Their programming *had* to operate under that assumption in order to create the illusion of reality in *our* world. And, by extension, when the holograms interacted with us, within the context of their artificial intelligence, we were no different than the other holograms—we were as real to them as they were to each other.

I realized in that moment that I'd been thinking of the Painter and the Skater in human terms, just as the crowd had. Internally, I'd been referring to each of them as "him" instead of "it." When did that happen? Was it in that first moment of indecision after the holograms had done something unexpected?

Thinking about it, I realized that in the midst of that momentary confusion, when I had interacted with them, I had acted as if they were as real to me as humans were. After I'd passed *through* the Painter—and nearly barreled off the edge of the scaffolding—the illusion was broken.

I still couldn't quite stomach one thing, though. When all was said and done, the fact remained that I'd actually developed some kind of a *relationship* with a hologram, no matter how brief and one-sided.

But I wasn't unique. When the crowd had witnessed that strange virtual accident with the Painter and the Skater, they'd all thought it was real at the time, so they'd opened themselves up to a flood of emotions normally reserved for humans. When they'd figured out it was all an illusion, they forgot about it and walked away, remarking about the clever illusion.

They'd developed a brief relationship with the holograms, too—or at least opened themselves up for one.

Which brought me back to Rachel. I'd developed what I thought was a relationship with her as well, when I thought she was real. It's just that the illusion went on for a much longer time.

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And her artificial intelligence had adapted to me, too—which made the illusion seem mutual and all the more real.

But, now that I knew she was a hologram, was she really any different from a comic book heroine to me?

How many people fell in love with comic book heroes and heroines? I already knew the answer; I went to comic book conventions, remember? It was amazing how many of us out there had what we felt were significant relationships with imaginary characters. . . .

It occurred to me that if I could develop a relationship with a hologram, even a one-sided one, then I could do it with a human, too. Couldn't I? If the dividing line between reality and these holograms could be *that* blurry, even for a moment. . . .

The Painter didn't seem to "like" me, but I *had* pushed him off a scaffold. Why shouldn't I expect his programming to respond the way it did? It was all part of the illusion, right?

And I really had *believed* Rachel liked me.

In that instant, I realized what my problem was, why I was sitting on a scaffolding contemplating suicide. It wasn't that Rachel was a hologram, it was that to other people *I was just like the holograms.*

I didn't have many friends because I spent so much time avoiding the real world, immersing myself in comic fantasy worlds, doing what I had to do to create the illusion of living here, without really *being* here. The other people probably just dismissed *me* as background noise.

I needed to spend more time in the real world, doing real-world things, straying more beyond the boundaries of my own self-imposed virtual world. It was time to go out of my way to meet new people, time to seek out relationships instead of waiting idly for the magic to happen. I needed to *participate* for a change.

I needed to live.

"Excuse me?"

I whirled at the girl's voice. She was pretty and petite, long blonde hair braided behind her. Bright green eyes sparkled against golden-tanned skin as she tentatively reached a hand toward my arm. "Are you . . . *real?*"

I nodded. "Yeah." I grabbed her hand and held it between both of mine. "I'm as real as you." Her hand felt good in mine. Solid. Real. Human.

She relaxed a little, but tugged her hand away from me. "Oh, good. Can you tell me where to find the Babylon Café?"

I pointed down the road. "Two blocks that way." I stared at her and wondered idly if *she* were a hologram.

Probably not, I decided. The Babylon had been around for generations; it didn't need to advertise. Besides, I had *felt* her hand. The holograms couldn't do that yet, could they?

"It's not as good as Dogies here, though," I said, smiling, standing a little straighter, hoping to project an image of more-than-casual interest, and jerked a thumb toward the burger joint across the street.

She arched an eyebrow, but said nothing.

I'd expected some kind of excuse like, "I'm meeting someone there," or, "I'm married," or something. But she didn't say anything, just arched that eyebrow, throwing the ball back into my court, so to speak.

"I'm Angus," I said, extending my hand again. "Want to get some coffee?"

"Joyce," she said, and her face lit up as she shook my hand warmly. "Sure. I'd love to."

We waited for the light, then crossed over to Dogies. As I opened the door for Joyce, I paused and looked across the street to see the Painter wave at me and smile. Joyce glanced there, too, but didn't seem to notice him. She didn't say anything, though, just looked back at me and smiled.

Rachel waved at me from across the

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diner and pointed to my usual table. As she turned, I swear I saw those weird wheels, spinning behind her holographic legs. Creepy. Joyce and I slipped into the booth and Rachel came over promptly.

"Hi, Angus. Your usual?" Rachel plopped down a couple of chipped mugs and splashed some steaming coffee in them, smiling broadly. "How about your new girlfriend?"

Girlfriend. I blushed at the label, but secretly I liked the sound of it. Yeah. My girlfriend.

"Two usuals," Joyce said, smiling at me, even though she didn't know what my usual was.

"You new in town, sweetie?" Rachel asked Joyce politely.

I was surprised to find my heart racing, then realized how silly I was being. Rachel wasn't real; she wouldn't care one way or another that I was there with a girl. Joyce was just another customer to Rachel, nothing more.

Rachel chatted with Joyce for a minute before attending to her other customers, asking about Joyce's job and her family, making friendly small talk. I listened raptly, genuinely interested. After Rachel left, it suddenly hit me that I'd heard those questions before. Rachel was running down a set of programmed questions designed to make Joyce feel like a special customer—just like Rachel had done with me for years.

And every other customer.

Someone once said you had to understand yourself before you could understand someone else. That someone was right. I used to think that other people were incomprehensible, but it turned out they were basically just like me. At the heart of it, they were all just looking for a little acceptance from someone else, just like I was. Some of them just didn't know where to find it, and some of them never bothered looking. I was lucky, I guess, because Rachel and the Painter and all the other holograms showed me, and it was so simple I don't know how I missed it before. All I had to do was open my eyes.

When I did, I found Joyce. And now, I felt great. For the first time in my life, I wasn't background noise.■

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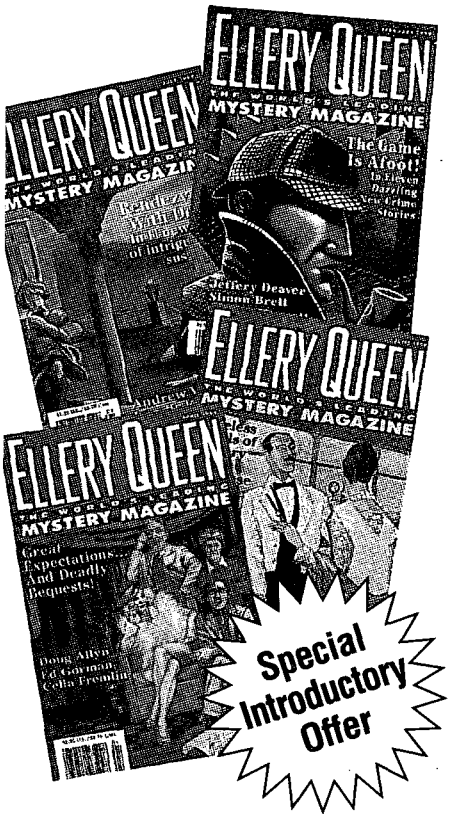

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CULT OF THE I

Kyle Kirkland

A variation on an old theme can be something frighteningly new.

Illustration by Nicola Cuti

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You can't transplant personality or intelligence by transplanting brain cells. At least, that was the theory we were taught as medical investigators. I'd always believed it.

Yes, I know about those old experiments: the ones where part of the brain of one animal was transplanted into the brain of another, and the recipient animal acquired some of the behaviors of the donor. Sure, it sometimes works for simple behaviors like daily rhythms. But it won't work for high-level traits like intelligence.

Remember the story where a person gains the knowledge of another person by receiving transplanted brain cells? Won't happen. In order to transplant thoughts and cognitive skills, you'd have to transplant the *whole* brain.

That was the theory and I never doubted it for a moment. Then I met Kat.

It was on a routine assignment. Routine, I guess, as far as these things go: cults kept springing up everywhere and most of them were harmless, even the ones that were the subject of strange rumors. One particular rumor was that a cult called "Individuals for Personal Freedom" was using brain-cell transplants involuntarily on some of their members. It was the ultimate brainwash and if true, would certainly make a travesty of their motto. But mind control is an old idea and at the time, as far as I was concerned, it was only a very stale rumor.

Be that as it may, the firm of Aldemeyer, Aldemeyer, & Laster, Medical Investigators, would take the client's money no matter what, even if what the client wanted to investigate was pretty silly. Well, that was Rob and Sophie Aldemeyer's philosophy. Me, I just went along for the ride.

The ride was often bumpy. As I walked into Sophie Aldemeyer's office and caught another one of her sour looks, I remembered how hard she'd fought to keep it Aldemeyer & Aldemeyer—no Laster. But Rob had gotten his way and his sister was a poor loser.

"Rex," said Sophie, her expression as if she'd just seen a two-inch roach crawling up her stocking, "you might be interested to know that Rob wants to talk to you."

"I just did. Talk to Rob, I mean. He only said one thing. 'Talk to Sophie.'" I sat down on one of Sophie's exquisitely upholstered chairs facing her desk. Sophie must have done something recently to get Rob's goat—otherwise he would have filled me in on the case himself.

She watched me for a moment. Sophie was about forty-five years old, a pleasant-looking woman—except when she was talking to me—who was very smart (possessor of both an M.D. and an M.B.A.). She also dressed to perfection; today she had her shiny brown hair pinned up and she was wearing a pale green pantsuit. I knew exactly what she would say next.

"Unshaved, sloppily dressed, slouching." She made it into sort of a checklist. "You had eggs for breakfast, didn't you?"

I took a tissue from her desk and wiped my beard. "I live the part, Sophie. I'm the field guy around here." That's why Rob let me join the firm and I well knew it. Most medical investigators work in labs for the police or government agencies or insurance companies—and thus have other people to do the legwork. But some of us go into business for ourselves, which means we have to go into the field to get the necessary data (or hire someone else to do it, which isn't always a good option, especially in delicate cases). I, for one, enjoy a more active lifestyle.

"You're not in the field right now. You're in my office."

"But I'll be in the field soon. You've got an assignment for me. Right?" I smirked and held up the used tissue. "You got a trash chute, or do you just sweep everything under the rug?"

She pushed a button and a large slot

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sprang open. I tossed the tissue in, banking it off the wall.

"Our clients," said Sophie, "are concerned about their daughter, Katarina. A straight 'A' student as a junior at Bryn Mawr—or was, before she joined the Individuals for Personal Freedom."

Every time Sophie talked about a cult—any cult—she got the same disgusted expression on her face that she always gave me, magnified ten times.

"So she hooked up with the IPF," I said. "So what? Did she drop out of college?"

"As a matter of fact she did." Sophie smiled without humor. "She's now a stripper."

I shrugged. "It happens." But it explained why the parents contacted us.

"Furthermore, there's a rumor . . ."

I didn't really listen as Sophie described the brain transplant rumor. I'd already heard it and, as I said before, I didn't believe a word of it.

You might think there's no chance that anybody could get away with doing something like major surgery and keeping it secret—especially from the victim. Actually, it wouldn't be that big a problem. You'd be surprised how trusting some people are when it comes to doctors—and how naïve most people can be about their own body. Besides, with today's equipment the surgery is practically routine.

The reason I paid no attention to those rumors is that they're *always* there. It gives each cult a sort of a mystique. Never mind that the rumors are about as real as Santa Claus.

In fact, I have nothing at all against cults and I didn't see why any of them even *needed* to manipulate their members. Most of them appeared to be simply an extreme form of a club or a frat or a lodge. I kept ribbing Sophie that our association—The Medical Investigators Association—is nothing but a minicult. But I never said that when she had a sharp object in her hand.

Sophie's objection to cults is that there are too many of them and that they're responsible for the presently fractured state of society. According to her, we should all try to live and work together. However, as I kept reminding her, "we" just don't have all that much in common these days: there's no unifying religion, no common set of beliefs or principles or codes of conduct. Everyone does their own thing, or sometimes they do it with small groups of other people who get together just for the purpose. As long as they aren't breaking any laws, it's not so bad.

"Rex," said Sophie. "Your eyes are glazing over. Am I talking too fast for you?"

"No. I just wasn't listening."

"Of course not. Why should I expect otherwise?" In a quiet voice she gave a few instructions to her computer, preparing several documents for transfer. Then to me she said, in an icy tone: "Individuals for Personal Freedom. They're becoming increasingly politically active, calling for a complete absence of any and all restrictions. That's the right cult for *you*, isn't it? Did you know that some people call it 'the Cult of the I'? It's growing quickly and that's hardly a surprise. The epitome of our times. I, I, I. Everyone always says 'I.' Never 'we.'"

"Some people are better off alone. Some people just can't get along." I winked. "Unlike you and me."

Sophie looked me daggers. "Ready for transfer?" she growled. "Then you can look at the information at your leisure. Sitting somewhere *else*."

I switched on my Portable Assistant. "Ready." It glowed briefly, then I put it back in my pocket.

"Goodbye, Rex. You should have a lovely time on this assignment. Imbibing noxious, mind-altering potions and watching women remove their clothing. It sounds nicely suited to your tastes."

"I'm looking forward to it. You want to come along?" I shot out of the doorway before Sophie could get a good grip

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on her sharp-cornered and perfectly throwable Desktop Assistant.

Katarina was currently enjoying a successful run of performances in a well-patronized establishment on Sutherly Street in Philly. I knew the area well; our home office was in Jersey and it was a short trip across the Delaware River. I went there often in the course of my work.

Okay, so I also went to Sutherly a lot even when I wasn't on a case. It was the place to go for people who like to do their own thing.

The name of Katarina's club was "The Brahman Bull." It was a stylish, upscale place—not exactly my cup of tea and I hadn't ever been there before. The cover charge was fifty bucks.

Katarina hadn't been working there long, but already she had top billing. A huge poster that decorated the entrance as well as the lobby featured a sexy woman in a feline costume: "Kat" was her stage name.

Brahman offered you a choice of four rooms. I skipped the foxy boxing, the mixed-gender wrestling matches, and the male strippers and headed straight for the main event. I wasn't the only one—the room was packed. Kat really drew 'em in. I sat at a table in the back.

For the next half hour, I was bored, drinking something called "Grecian Elixir" and watching a series of forgettable women sporting boob jobs, laser surgery, stem-cell therapy; the works. Even though the lights were soft—a kindness that the older women probably appreciated—and even though I was well away from the stage, I could see all the signs of cosmetic enhancements. Not that it was important: just professional pride, being able to tell how it was done.

The second Grecian Elixir was settling in my stomach and I was beginning to wish I had taken a dose of alcaway. It metabolizes alcohol quickly before the brain becomes intoxicated, provided you don't drink too fast; usually I don't need it, but whatever was in those elixirs was pretty strong stuff.

With no sign of Kat, I got up and headed for the bathroom. I had taken a few steps away from my table when a woman came running into the room from a side door that had suddenly opened up in front of me.

For a moment I stood there, right in her way, and she managed to stop before running into me. I didn't recognize her at first, but after a second or two I realized that it was Katarina. No one but me had noticed her yet. After the smallest hesitation she ran past me, brushing her hand gently and deftly across my beard as she flew by.

All of a sudden the room grew completely silent. Every eyeball turned to the woman who was prowling around the audience. Jeez, they didn't even announce her.

Not that she needed it. She was wearing a suggestive but relatively modest outfit adorned with leopard spots, and she had a few whiskers playfully pasted to her upper lip. I went back to my seat.

Kat pounced onto the table of a very surprised group of men near the edge of the stage. Hoots and hollers followed her as she walked catlike, on all fours, around the tabletop. She purred and I heard it as if it were right in front of me—the acoustics were marvelous. They must use microamplifiers and speakers tethered to the tables or to the ceiling; it seemed as if Kat were speaking directly into my ear.

With no advance warning, she leapt in a single bound onto the edge of the stage. I recalled reading in her bio that she'd done gymnastics in high school and had become pretty good at it, even turning down a scholarship.

I couldn't believe what happened next. This astonishing woman hung there, at the very lip of the stage, seemingly in thin air. With both hands grasp-

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ing the edge of the stage she lowered herself, in perfect control, down to the floor, all the while holding her legs in a provocative pose. Talk about your captive audience.

Mesmerizing. It wasn't just her good looks—natural good looks, as far as I could tell—and her grace. She was also great with eye contact. I noticed she was careful to look at pretty much everybody at least once.

Great performers make time go by fast. It seemed like her show was over in just a few seconds, and then I looked at my watch and found out fifteen minutes had gone by.

The effects of the Grecian Elixir were nothing compared to Kat. Most of my drink had ended up sloshed on the table anyway.

I stayed for the second show. I would have stayed for the third, but there wasn't one, so I left right after the second. Armed with a bit of information that every other man in the place would have killed for, I hopped on the night-owl trolley.

Following the directions on my Portable Assistant's map, I hurriedly made my way to a townhouse in the middle of a somber but not too dreary neighborhood. Like most IPF people, Katarina shunned public transportation, but I had enough time to beat her home.

I got my equipment ready. This was the best part of the business for me: using the tools of the trade out in the field. About eight years ago, when I was a newly minted medical investigator—and the business was pretty new then too—all of us did a lot of field work. The move to "armchair" investigating, which M.I.s are so famous for, only came later. The big guns had to justify our existence somehow, and that was how medical investigating became distinct from similar types of occupation: we're doctors who work in hospital-like settings but don't see patients—only data.

Ten minutes later, a car pulled up to the curb. I had just finished slipping on my medico contact lenses.

Katarina hopped out, and I was not at all surprised that this twenty-two-year-old superwoman still had a spring in her step. It was about 2:00 in the morning, so I moved into the light of a street lamp and tried to make myself appear as non-threatening as possible.

Katarina confidently strode past me. She smiled at me—what a smile! Her whole face lit up. If she was afraid of me, she wasn't showing it. "Enjoy the show?" she asked, as she climbed the stairs to her house.

Suddenly I forgot what I was going to say. How had she recognized me from that relatively dark room at the Brahman? Or was she just guessing?

I floundered until it was almost too late. Just as she flicked a wand at the door to open it, I blurted out, "Your parents are worried about you, Katarina."

She hesitated, then turned to face me. I took a few steps up to her porch.

"I was sort of expecting this," she said. "You a private detective?"

"Something like that. But it doesn't matter. What matters is that your parents care about you. They're concerned."

With a slight movement, I centered her head in the beam coming from my Portable Assistant, which was safely tucked away in my shirt pocket. My lenses shifted the beam's frequency to the visible range for me, so that I could make sure it was on target. I snapped some pictures while holding my breath—a jitter would cause a loss of resolution and make interpretation difficult. Katarina unknowingly cooperated by standing like a statue at her doorstep. I got several different angles.

"Look," she finally said, a tone of exasperation creeping into her voice, "I love my parents very much. But I have to be myself, and right now that just happens to be a performer. Maybe mom and dad don't like it, but that doesn't make it wrong. Parents can't live their children's

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lives for them. We, all of us, must be free to be who we want. That's why I joined the IPF, and I'm glad I did."

By this time I had all the pictures I wanted, but I found myself staying longer—Katarina's smile, probably. "My parents wanted me to be a doctor. I wanted to be a policeman. So we compromised."

"You're an M.I.," said Katarina. She thought about that for a moment and then started to frown, her gaze moving downwards. I realized that it was a big mistake to let her know. In a quiet voice she said, "They must think I'm crazy or something."

"No, they don't. They know you're not crazy. But look, it's a long jump from Eudora Welty to the Brahman Bull, and that's why everyone's curious." While at Bryn Mawr, Katarina took a serious interest in Classical Literature, particularly in female writers of the southern United States. Welty was the only one I could remember from my old freshman Lit course, and I really had to reach deep to pull out even one name.

As I had hoped, that brought out another one of her brilliant smiles. "You really do your homework. Well, doctor, I'm tired and you've probably already got all the med scans you need, so I'm going to call it a night." She winked and said, "I'd invite you in, but I don't socialize with strange men, including doctors. Even ones who know who Eudora Welty was."

Softly she closed the door. I stood there for at least ten minutes longer.

Rob refocused the projection one more time, and I sat there sick of looking at the object that I'd seen and scrutinized and sweated over for hours. It was a skull, plain and white and perfectly normal.

"There's nothing unusual here," said Rob.

Rob, Sophie, and I were sitting in the room we used for projecting and inspecting med scans. The picture was sort of a hologram, a 3-D job in which you could shift the perspective by simply changing your viewpoint. We had frontal, occipital, parietal, and temporal shots. None of them had any suspicious marks, at least at the limit of our resolution.

"Nothing strange in any of these scans," continued Rob. "That's fine. We've got good news for Katarina's parents. Well, good and bad, I guess. Good that she's not being medically manipulated. But that means she's naturally a little bit on the wild side. Sort of an unsettling thing for a parent to learn, considering genetics and all."

I shifted in my chair. "I'm not totally convinced."

Sophie raised an eyebrow. "I thought you were the one pooh-poohing all of these brain transplant rumors."

Rob took another glance at the scan. "Yeah, Rex, and I'd say your skepticism proved right. The only sutures on this skull are natural ones—where the skull bones met and grew together early in life. No one's ever made a burr hole of any decent size or done a craniotomy on this gal or we'd see it here. The cranium is uniform with no hint of recent growth or repair. So why aren't you convinced?"

"Maybe there's another way of making a brain transplant," I muttered.

"What other way?" Rob looked puzzled. "The blood-brain barrier doesn't allow a vascular route. The only things that can get into the brain that way are small molecules, and nanotechnology hasn't progressed anywhere near to the point where it could do the job."

Sophie gave me a suspicious glance. "You're looking nicely groomed today, Rex. Hair combed, beard trimmed, clothes pressed and clean. Quite presentable." She had a knowing look that was disconcerting.

"I'm not in the field today."

"Furthermore," said Rob, totally ignoring the last exchange between Sophie and me, "whatever that cult is doing, if anything, it must be subtle.

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Pharmacological, maybe. But there are only a tiny number of *subtle* drugs. Usually their effects are obvious and difficult to control, so I doubt if a cult would gain anything by using them, except for recreational purposes. Anyway, that's out of our league. Katarina's parents can contact the pharm people if they want, but she's evidently experienced no surgical manipulation."

"I don't know," said Sophie. "Maybe Rex has a point. New developments happen all the time, and sometimes they don't get into the scientific or medical literature right away. The leader of this cult is a man of dubious character whom I wouldn't trust for a minute. I think this job might be worth pursuing a little longer."

"I disagree," said Rob. "And almost every man is of dubious character to you, Sophie. Besides, the whole thing is ridiculous anyway. Transplants wouldn't be useful for mind control or sculpting personality—we all know that. We knew it before we started this case. If there's been a manipulation, its effects have been subtle, because Katarina isn't suffering from any motor, sensory, or cognitive defects. That's already been checked. Nothing major has changed: she just seems to *think* differently about things, according to her parents. But drugs, transplants, electrical stimulation—all of those things are about as subtle as a sledgehammer. They have a lot of side effects that you just can't control. If she were being manipulated, we'd see *something*. Surely you agree, Rex." Rob shot me a questioning look.

I could only shrug helplessly under Rob and Sophie's stare. "It's just a feeling I have."

Rob grew impatient. "Based on what?"

"Her personality, I suppose. Something's wrong. She's changed."

"But you didn't know her before," said Rob.

I felt like I'd known her all my life. Maybe I had—in my dreams. Not that I'd ever tell that to Rob, and especially not to Sophie. To me, Katarina was almost perfect. *Almost*. There was just this one thing about her that was out of place, some little detail that was just not right. But I couldn't elaborate; I could only give Rob another helpless shrug.

"I'm sorry, but we need more than that to go on. As far as I can tell, there isn't a shred of evidence that anything of medical significance has happened to Katarina and that's what we have to report. Sure, maybe it's something new that we didn't or couldn't detect, but we won't get anywhere worrying about that. We have other clients and other jobs and not enough resources to go around. This case is closed."

The phrase "something *new*" somehow stood out. But it was a long time before I realized why.

I spent the next three weeks thinking about it. The more I thought about it, the more I understood—and was afraid—that Rob was being perfectly reasonable.

But it didn't matter. The feeling—whatever it was—wouldn't go away. Something was wrong and I was determined to find out what. There were other cases to work on, but they were just nuisances, draining my time. Every spare moment was spent on Kat.

Visits to the double B were a nightly occurrence. Every night that Kat was on, I was there. She noticed, too. At first I didn't think so; although she looked at me every once in a while, she didn't give any sign that she remembered our meeting. But she remembered, all right: one day there was a package waiting for me at home. It was a book—not electronic, but a real book with old-fashioned pages and everything. *The Robber Bridegroom* by Eudora Welty.

So Kat had done a little homework on her own.

It also made me think about something else. The word "old" circulated in my mind.

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All the while, I was digging a little deeper into the IPF. There was a problem with that: Rob had closed the case and thus I had no client and no authorization. The association was very strict about things like that. Investigators have access to a lot of resources—medical and hospital records, police files, and the like—but we're not allowed to look at them unless they're directly relevant to an ongoing case. That's supposed to keep snooping in check (and Congressional hearings to a minimum). It worked on the honor system, so there was nothing to stop anyone from being dishonorable. Of course, if the association found out, they'd do a little dissing themselves: like yanking my M.I. license.

So I snooped. But just a little bit.

The IPF "president" was a nondescript man who'd had a relatively nondescript career. First he was an account executive at a brokerage, then he moved to advertising, and finally he started his own business—as you would expect for someone who would ultimately become an IPF big shot. The only time he'd gotten into trouble was six years ago, when an IRS audit uncovered a tax shelter that really wasn't, for which he received the obligatory slap on the wrist.

But it was his interest in history that really caught my attention. That brought up memories of an old med school professor who used to say that many so-called new developments were just old developments in new garb.

There was something else. I found it early one evening: a document the IPF president had written many years ago, when he first got involved in the cult. It wasn't their manifesto or anything, just a simple article that had been posted on the web and long forgotten, until my search engine dredged it up from some dusty old cache.

I read and studied it late into the night. After looking at it so long that my eyes began to ache, I configured my Desktop Assistant to read it to me.

". . . all of us harbor a great deal of inner strength . . . this enables us to attain the maximum degree of personal freedom . . ."

Sleep began to overtake me, but I fought it off a little while longer. ". . . stimulation may be necessary to bring it out. Oftentimes, severe hardship will do the job. Asceticism has its merits . . . unfortunately, it's too demanding for most of us . . . we must find a way to stimulate this strength . . . without a lot of suffering . . ."

I lay in bed late that night thinking about it. It reminded me of the unsavory past of medical psychiatry. I thought about electroconvulsive treatments for depression, in which the brain was shocked into having seizures. And treatments that cut out part of the brain, like the old "psychosurgery": the frontal lobotomies that supposedly made violent patients docile.

I must have fallen asleep at that point.

Early the next morning, I learned that Katarina was taking the performance business to yet another level: a reality show called "Dare Ya!". Katarina's dare involved a 100-foot drop and no margin for error. It was scheduled for that very night.

But I couldn't let it happen.

It was about 6:00 before the "Dare Ya!" studio opened up, and I was the first one in line.

"See your dig-sig?" asked the attendant who barred the way inside. He held a palm-sized monitor and glanced at it impatiently.

The only audience that these reality shows allowed was a few dozen people who were merely there for verification purposes. Almost any stunt was easy to fake on video, so the reality folks had their shows watched by a small live studio audience who would vouch for the authenticity. The digital signatures of all members of the audience were available for inspection over the Web. Presumably that made it more exciting for the people watching at home.

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My name wouldn't be on the dig-sig list. "M.I.," I said, instructing my Portable Assistant to transmit the appropriate code. The attendant nodded and let me in.

Any *official* visit would be authorized by the producers or by someone who was involved in the production. Mine wasn't. There goes the M.I. license: six months suspension, at least. Rob would go ballistic.

Of course, if I was right about Katarina . . . But all I had was a feeling.

I finally found the tower after about half an hour of wandering around. Katarina was perched on a little beam that was like a diving board, except it looked to be rigid and was only a foot or so wide and very thin; it extended out over the landing pad, and Katarina was ready for her swan dive. The landing pad was about ten-by-ten, 100 square feet. I recognized the material. It was a special rubber that rapidly converts stretching and strain into heat—which is fine, since it won't bounce you like a trampoline would, but if you hit it too hard, it can get plenty hot.

Lights and recording devices were everywhere, but the ladder leading up to the tower was pretty dark. I started climbing.

Why would anyone want to watch this spectacle? I guess maybe that's their own thing—although I was beginning to think of this particular thing as very uncool. I'm sure the show's producers got Katarina to sign a stack of waivers and promises not to litigate if something were to go wrong.

But something was already wrong. Katarina was wrong and she didn't know it.

I reached the top before anybody except Katarina noticed me. But then shouts came from below. There wasn't much time. I eased out on the razor-thin beam, straddling it with my legs and scooting along on the seat of my pants.

I was worried sick that whatever they had given her was now out of control. Although she hadn't had any noticeable deficits earlier, what about now? The IPF wouldn't care if they lost one of their members; they'd simply lower the dose or something on the next one. And if they had found out I'd been snooping, they might have decided to terminate this particular experiment right here and now.

Katarina watched me with a combination of surprise and amusement. "Careful, Dr. Laster. I don't know what you're doing here but we ought to go back to the tower. I'm not sure this thing will support both of us."

"No, let's stay here for now." I was counting on using the thinness of the beam to keep security at bay for a while; I'd have to white-knuckle it. Kat was at the end of the beam and I moved out as far as I dared, keeping my back to the platform. "I want to talk to you."

"About my weird behavior?" A smile.

"And my weird behavior. You see? It's catching."

"Are you supposed to be here?" Katarina glanced downwards—something I really didn't want do at that moment. "It seems like the producer down there wants to get your attention."

"So do all those nice people wearing uniforms and guns. Katarina, I think somebody did something bad to you."

"Did they do the same to you?" Katarina adjusted her costume; it must have been uncomfortable, since it was equipped with at least four small nozzles—tiny maneuvering jets. The supply of compressed air was apparently concealed in a small backpack. It wouldn't be easy to use the jets correctly if she started to tumble in midair; she could just as easily thrust herself off-target and she'd have to be exceptionally fast to react in time.

"No, they didn't do anything to me. I'm naturally crazy."

Katarina gave me another one of her pinball smiles—her eyes lit up like diamonds in the sunlight.

And it was her eyes that suddenly gave

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me the answer to the puzzle. "Eureka!" I shouted—and almost slipped off the beam. Glancing down, I almost became ill. Those security guards looking up at me appeared to be awfully small. . . . A surprisingly strong hand grasped my shoulder as I teetered and swayed.

"Careful, Dr. Laster! You really are crazy if you stay on this beam. Please, let's go back. Now!"

"No, no. I just figured it out. I know what's wrong. At least, I'm pretty sure—it's the only thing that fits. I'm naturally crazy and you are naturally *competitive*. What they did is to make you more so. *Un*naturally."

"How?"

"Listen, we don't have much time. What they did was use a very old-fashioned way of . . ." How can this be put delicately? And quickly! "About eighty years ago, doctors developed a technique of doing frontal lobotomies—they didn't cut out the frontal lobe, they just disconnected it from the rest of the brain. They used it on violent patients, but the treatment was too controversial and was replaced with other methods."

"I don't understand what this has to do with me." Katarina pointed behind me. "And that guard has almost reached the platform. You're running out of time."

One backwards glance told me she was right. "The way the operation was done was to slip a thin, sharp instrument around the eye and then slice up the surface of the frontal cortex. Quick and easy—it was an outpatient operation!"

Katarina gasped. "Are you trying to tell me that—"

"No, no! It's the other way around. They didn't cut anything or take anything out. They put something *in*, Kat. Cells. Neurons. Neurons that are releasing chemicals, probably neurotransmitters. That's the way they 'stimulated' your 'inner strength.'"

"Wait a minute." Katarina paused. "I did have an outpatient operation a little while ago: laser surgery to correct my vision, so that I wouldn't have to wear contact lenses anymore."

"And the doctor?"

Katarina frowned. "She was recommended by the IPF. In fact, it cost me almost nothing—she was a member too."

Aha!

"It's all right!" shouted Katarina, to the security man who'd arrived at the base of the platform. "He's okay!"

"Yo, buddy!" The cop gestured to me.

"Do you mind?" I screamed. "The lady and I are trying to have a private conversation here."

Katarina smiled again. "You're an interesting man, Dr. Laster. But I'm still not convinced that you're right."

"Call me Rex. Listen. The frontal cortex is involved in planning and deciding and a lot of goal-oriented behaviors. Those foreign cells are there, stimulating your natural inclination to be a performer—the same inclination that encouraged you to excel in gymnastics and in school." It wasn't mind control, and it didn't exactly amount to transplanting personality, either. But it was bad enough. "Do you understand?"

She shook her head.

"Before, you were just well motivated. But now the signals are grossly amplified, and because they're coming from the frontal cortex, your brain is interpreting them as an irresistible urge to get all the attention you can get. Including doing questionable acts. Katarina, you need some help, and I'm going to give it to you. But you've got to trust me and stop this nonsense. You don't have to go through with this stupid stunt."

"Well, how would it look if I backed out now?"

"Yo, buddy!" bellowed the guard. "This is the last time I'm gonna tell ya . . ."

"Quite frankly," I yelled over my shoulder, "I certainly hope so!"

"Please, Dr. Laster." Katarina's eyes were now pleading, not smiling. "Rex. I don't want you to get hurt."

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"You don't realize how serious this is. How can I make you understand?" Other than doing something drastic like neurosurgery, it would be tough to determine exactly what they'd done to her. The cells that survived the transplant had almost assuredly integrated themselves into Katarina's neural circuits. It would be impossible to remove them except by taking out the affected part of her brain. Not an option! "We can probably figure out what chemical the cells are releasing by simply monitoring your cerebrospinal fluid," I said hopefully. "Maybe we can give you a drug to compensate, perhaps even to kill the cells chemically or by some other means. But it's going to be a lengthy process. It'll be like fighting a cancer."

That got her attention. "It could be that bad? But what if there's no cure?"

"Sure there's a cure: more of Rex Laster in your life." If I got her to cooperate, it should be possible to find out exactly what IPF had done—and stop them from doing it again. I'd need help; it would require a lot of effort and expertise and until something could be proven, I would be out of a job. Sophie would probably be willing to lend a hand for a good cause, even if it meant helping *me* at the same time.

"Rex, you're sweet. But I don't know . . ."

"Yes, you do. What you need is to use your talent and your energy for something worthwhile. I want you to go back to Bryn Mawr. I'll help you. In fact, maybe they need a medical educator on staff. I have a feeling I'm going to be available real soon."

A look of horror came over Katarina's face. I twirled around, thinking the cop had pulled a gun or was swinging a lasso. Instead, he was doing something much worse. He was testing his footing on the beam.

"It won't hold all—" Katarina's shout was cut off by a loud crack.

The beam didn't break all the way, but it angled precipitously downward—enough for me to lose my grip. I bumped against something sturdy—Kat, whose hold on the beam was a lot firmer than mine.

It was as if I hung in the air for a moment, kicking and flailing. Then everything started floating upwards. The fall only took a few seconds.

I hit the rubber close to the center. But I couldn't take much credit for the bull's-eye: with the angle it was in, the beam more or less deposited me on the pad. The material got much warmer than I would have expected, and I wasn't anxious to lie on it for long.

Later I found out that a photographer had taken a close-up of my face on the way down. My eyes were bulging and my mouth was a perfect rictus of terror. It was plastered on news screens everywhere the next day. That wasn't the only place I would see it: Sophie had it framed and hung it up in her office. She vowed that she would *never* take it down.

Katarina followed with a splendid landing. I felt even more sheepish: her motor control was excellent. Still, I couldn't blame myself for being worried.

She was amazingly nonchalant. "Well, our audience got two daredevils for the price of one, so they should be happy. Now I want you to start from the beginning and explain all of this to me. What does that medical stuff mean?"

We were surrounded by people and some of them—the ones wearing uniforms—wanted to grab hold of me. Katarina tried to hold them off with a frosty glance and a wave of her arm, but they managed to put handcuffs on me anyway.

"I'd be glad to tell you what it means, Katarina," I said. The police were leading me away, but Katarina followed. With the look that she gave me, I felt sure she would listen and cooperate. "It means that you belonged to the Cult of the *Eye*, but *we* are going to do something about it."■

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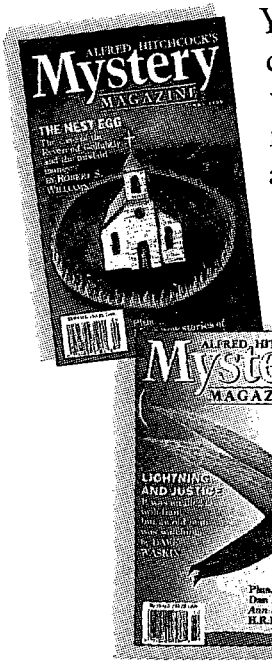

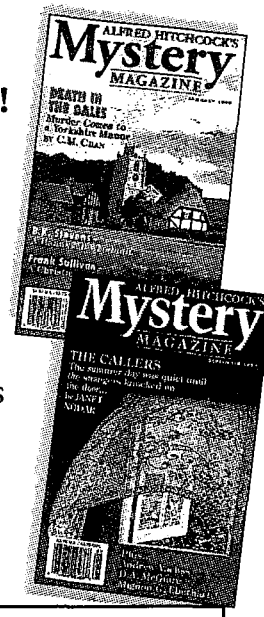

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The Ones Who Stay Home

Larry Niven

As capabilities grow, so do ethical dilemmas.

Passengers from *Wandering Signal* had come to the Draco Tavern in my hour of need. I thanked them for that, and I set about serving them.

Somewhere in the wreckage of the bar was a bag that looked like bird kibble. Blue Bubble would eat that, but there wasn't any point in looking. In this disorder I couldn't identify it. Too much of what I keep for my alien clientele looks like bags of kibble.

The Boojum would take salt water, a careful balance that didn't match Earth's oceans. I keep a jar of salts, and for a wonder, I found it. I mixed it with water—the tap was still running—and got the Boojum to test it for proportions.

The Chirpsithra need sparkers. Those I found. My wall sockets weren't delivering power. I was relieved to see the Chirps had brought a power pack.

Sissy didn't need anything.

I needed painkillers and an alcohol-free beer. We took it all to one of the intact booths. I had to let the Boojum do the carrying. None of my staff was present—Tony was still in the hospital—and I was still healing.

The bar—the Tavern's central pit—had taken most of the damage. Various force fields damped some of the blast. Most of the booths were intact, and a few still had float chairs and privacy fields. I picked a float chair to put me at conversation level with the Chirps.

"Yes, we fight," I said, continuing a discussion. "In most mammal species, the males duel for mating privileges or property rights. We humans still do a little of that. Hey, even caterpillars fight for territory. It's universal."

"That gives no mapping for what happened here," Blue Bubble grumbled, "this lethal vandalism." Blue Bubble was as big as our large airlock, and I couldn't tell what was inside it.

Sissy was an energy pattern who lived in a bell jar of thin ionized plasma. Her native habitat was at the rarefied edge of a gas giant planet's atmosphere. Her life processes gave out a thin, wavering hiss.

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She spoke through a standard translator. "In the archaic state of nature," she said, "we might wrestle to overwhelm each other's magnetic patterns. We do this to gain dominance within a vortex. Victor superimposes its memory on the loser. It is not normal to die in battle, but it can happen. Patterns merge and conflict, a flare, both gone."

"Then you don't have a problem with terrorists?"

"A tale out of history," Sissy said to me. "Wesshenss Bondbreaker's family vortex built an iron kite and ran it into a stratospheric storm. The tail he guided into a meeting of the Guidance Vortex. Half the Guidance was blown out. Wesshenss disrupted too. Would you call Wesshenss a terror maker?"

I said, "Not unless he was trying to frighten someone. Wesshenss was trying to *kill* the Guidance, wasn't he?"

"Yes. I don't understand this term, 'terror'."

"Extreme fear," I said. "It isn't what one can do to an enemy, it's what one can make an enemy do to itself. If one can put an enemy—country, political entity, culture, whatever—in a state of terror, the enemy may do crazy things."

"It's not a useful term," one of the Chirpsithra said. The two looked identical—slender lobsters eleven feet tall—and I didn't try to tell them apart.

Blue Bubble said, "When we fear an enemy, we fight him. Why would any entity want us to fear him?"

"Among us there is doubt as to what is a person," Sissy said. "Attacker and defender may merge or trade packets of information. One may become the other. Your Golden Rule is mere common sense to us."

The Boojum said nothing.

"Terrorist is not for us a useful term. You must understand," one of the Chirpsithra said, "that no entity would achieve interstellar flight if extreme forms of vandalism were a problem. The energies involved are too great. The power in *Wandering Signal* would shatter most habitats. Planets, for instance."

"What do you do about vandals?" I asked.

"Many things. Our greatest threat is from the dead Universe, from kinetic energy, from impacts large or tiny. Most tool users cannot match the fury of a meteor impact or a blast of cosmic rays. We make the ship self-repairing. We blast small intersecting masses and steer around large ones. These same defenses would repel many potential enemies."

"Design flaws," the other Chirp said. "Things go wrong with any machine or system. We build to resist accidental damage. Thus the ship will also resist imposed damage, sabotage."

"We don't land the mother ship," Chirp One said. "*Wandering Signal* now orbits the Earth's Moon. Wherever entities probe the Universe more deeply than you have, we still leave *Wandering Signal* out of easy reach."

Chirp Two leaned toward me. "Rick, your people say 'terrorist' and 'freedom fighter' and 'soldier,' 'espionage' and 'murder' and 'homicide,' as if you must know an enemy's motive. You deal with only one species. It must be easy to predict what people of your own kind will do. But we deal with a myriad kinds of intelligence.

"More than that, there are deviants. Few species evolve toward the conditions of interstellar travel, therefore it is deviants who board our ships. We must be very wary of our own passengers. Even ourselves, even crew may go mad.

"So, our concern is not with who might try to damage us, or why. Some of you use another term, 'threat estimate.' For every creature or hive or plausible grouping, there is a threat estimate. How much damage could it do to us? How shall we protect against it?"

"That sounds insanely complicated," I said.

"Intrusive," said Blue Bubble. "We were probed down to our atomic structure before we were allowed to board. We entered *Wandering Signal* naked,

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and found life support inside. All are so treated. What the crew learns is useful for medical treatment, so we are told."

"That sounds likely," I said.

"Objection!" Blue Bubble said. "Medical repairs interfere with our ongoing evolution! What if we refuse the probes?"

"Stay home," one Chirp said.

"To stay home is easy," the other said. "Stay within the bounds of one's evolution. Stay where dangers are known. Most sapient species can't travel. They would need life support so extensive that they could not perceive the Universe beyond. Information flow is so easy. Why do we go?"

I asked, "Why did you?"

She didn't answer. I looked to the Boojum, who said, "I was made, an elaborate multisensual camera. I was to carry sensations home to my makers, who were not able to leave their swamp. The swamps dried despite all efforts. To stay home is only relatively safe. May I show you some of the wonders I have collected?"

I said, "My systems are down."

"But the danger to *Wandering Signal* suggests its own solution," Blue Bubble said. "Why not bar everybody? Why not explore as the Boojum's people do . . . did?"

I thought: why doesn't Congress shut down all airports?

The Chirp said, "Knowledge. All this mingling of near-infinite varying viewpoints is certain to produce new tools, ideas, techniques, philosophies, art. Whether these things are worth the risks is a judgment call. A tiny few of us choose to travel. Ten-to-the-fourteenth Chirpsithra stay home, those who see risks as greater than rewards."

Blue Bubble said, "Yet you claim all red dwarf stars."

"Only travelers settle other worlds, mate and breed. Most Chirpsithra descend from travelers. Most of every species worth talking to descends from travelers."

I said, "Robert Heinlein once wrote that you do not truly own anything that you can't carry in both arms at a dead run."

"Yet you stay home, Rick Schumann," said one of the Chirps.

"And look what that got me."

"You will rebuild. Somewhere among your population are the vandals who attacked the Draco Tavern. They will be brought to our justice. We have set Folk in charge of finding them. Half our passenger complement is playing the detective game, enjoying themselves greatly, building or borrowing forensic techniques—"

Like a role-playing game, I thought. Wait, now— "The Folk?"

"Who better?"

The Folk are hunters. They don't eat unless there is prey to track down.

The thought gave me a moment's vicious pleasure. Then I asked, "What if there are a lot of terrorists involved?"

"The law is already established. One of us died in the explosion. They belong to our justice. Why would numbers matter?"

Whole nations had backed the killers who brought down the World Trade Center. The bomber who attacked the Draco Tavern might represent a political party, a nation, a religious movement, or—it was not beyond possibility that a whole world could be held responsible.

I said, "A sense of proportion can be a valuable thing."

Trucks were pulling up outside. These must be the repair crews I'd asked for, though of course they'd have to get through our security. "I'd best deal with this," I said.

One of the Chirps said, "Vandals of a species now deceased once destroyed a planet housing four times ten-to-the-ninth of our kind. What sense of proportion should we have shown then? Would it matter that most of us escaped?"

But men in hardhats were waving at me, and I went to answer them.■

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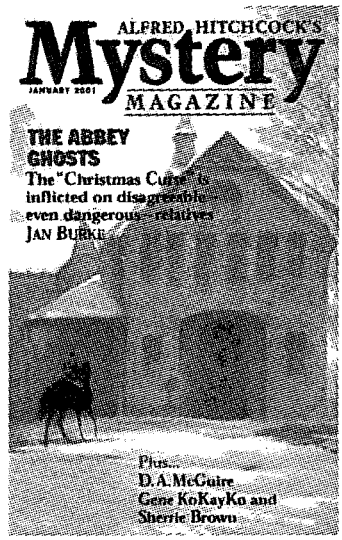
SOME PEOPLE WOULD KILL...FOR A COPY



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THE ALTERNATE VIEW John G. Cramer

THE NEW RECYCLING UNIVERSE

In this column I want to describe a new possible description of the Universe, a cosmological paradigm proposing a Universe that is infinite, eternal, and that recycles itself from Big Bang to Big Crunch at regular time intervals. This new model of cosmology is the work of Paul J. Steinhardt of Princeton and Neil Turok of Cambridge, and is inspired by string theory and based on Steinhardt's own ekpyrotic cosmology, as described in a previous AV column ("Brane Bashing: Big Bang or Big Clap?" *Analog*, April 2002).

A cyclic Universe, a world that goes through periodic cycles of destruction and renewal, is a classic theme of many mythologies and religions. There was also a decade or so in the mid-twentieth century when recycling Universe models were quite fashionable in physics circles. This was after theoretical physics had taken on the job of describing possible scenarios of the origin and evolution of the Universe using the mathematics of Einstein's general relativity, but before the average mass-density of the Universe had been measured with any accuracy. The cyclic cosmology hypothesized that our Universe started with a pointlike Big Bang singularity that expanded to its present dimensions. In the future, it would continue to expand for a while and then "stall," as gravitational forces overcame its outward expansion momentum. From the stall point, it would recollapse to a Big Crunch, bounce, and the whole process would repeat with regenerated and renewed matter and energy. There was a debate as to whether time would run forwards or backwards during the collapse phase. The recycling Universe scenario was recognized to have a certain ecological appeal, because no matter how much garbage, mess, and pollution our civilization creates today, anything and everything will eventually be crunched together, renewed, and restored.

However, the cycles of the recycling model were discovered to be imperfect. Richard Tolman showed in the 1930s that a recycling Universe would accumulate entropy (i.e., disorder), so that it would bounce to a larger size and would contain a different quantity of mass-energy with each cycle. Thus, extrapolating backwards, some past Big Bang would have to have been the first. Therefore, the cycling model is not eternal. Some cycle must be the first, and the appeal of an eternally recycling Universe is lost.

More recently, astrophysical estimates of the average mass density of the Universe have shown that there is not enough mass in the Universe (by roughly a factor of 3) to produce a closed recycling Universe of the kind Tolman envisioned. Therefore, the fall-back to a Big Crunch and the cyclic Universe models have been abandoned. The current inflationary Big Bang scenario, which has become our standard model of cosmology, describes a Universe that starts from the Big Bang and continues to expand forever, apparently with the rate of expansion increasing with time.

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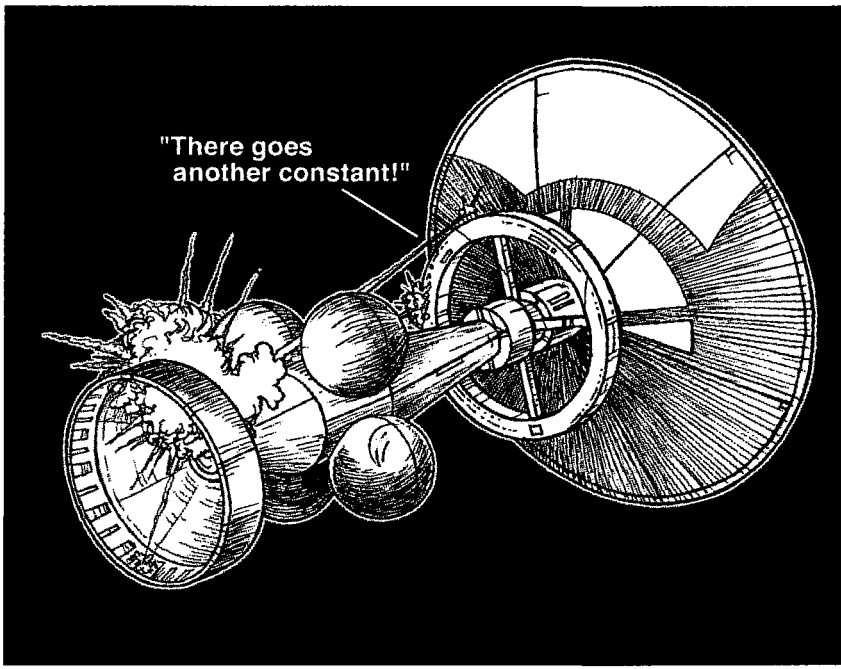

Illustration by Wolf Read

The standard inflationary Big Bang scenario, while very successful in accommodating most of the astrophysical observations about our Universe, has several problems. First, there is considerable difficulty with its starting point and the physics at the initial singularity, where the mass-energy density must be infinite and the laws of physics become "inoperative" (as they used to say in the Nixon administration.) Contemporary physics is incapable of describing the starting point of the Big Bang. Even at the slightly later stage of the scenario, during which the Universe is undergoing a superluminal "inflationary expansion," the inflation does not follow naturally from the mathematics of the model, but rather must be put in "by hand."

An additional problem for the inflationary Big Bang scenario comes from the recent observation from studies of distant supernovas, supported by small-angle variations found in the cosmic microwave background. These data imply that the expansion-rate of the Universe is itself increasing, perhaps under the cumulative negative pressure of "dark energy" in the vacuum itself (see my AV columns in the May 1999 and January 2001 issues of *Analog*). Standard Big Bang cosmology did not anticipate this discovery, and it must undergo some meticulous fine-tuning to accommodate it. For the Big Bang model, it's a case of *"Who ordered that?"* as Wolfgang Pauli asked when the mu lepton (a heavyweight electron) was discovered unexpectedly.

The new Steinhardt-Turok cosmology offers several advantages over the standard Big Bang model in dealing with these problems: (1) it has no singularities, and therefore never reaches a Planck-scale energy density at which the laws of physics might fail, (2) it requires no inflation phase, and therefore needs no explanation for why inflation might have occurred, and (3) the observed

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dark matter, dark energy, and accelerated expansion of the Universe are all natural consequences of the model.

How does it work? The trick is that the expansion and collapse of the Universe does not occur in normal space, but in an extra (and unobserved) dimension occupied by gravity (see my AV column in the December 1999 *Analog*). The model has one time and four noncompact space dimensions (with any extra dimensions "compactified" into small loops). The four-space is delimited by two three-space boundaries or "branes," one of which has positive tension (i.e., energy) and the other negative tension. Our Universe is the positive-tension brane. All the matter in our Universe is constrained to reside on that three-dimensional brane, and is not allowed to venture out into the 4th dimension, which separates the two branes. Only gravitational forces may cross the extra-dimensional gap. Therefore matter in our Universe feels the gravitational influences of matter and energy on the other brane as well as ours, and is influenced by fields that fill the four-space.

The starting point of a given cosmological cycle is what I called in a previous column the *Big Clap*. There is a force between the two separated branes that causes them to move with respect to one another, and when they momentarily come together, the resulting "clap" fills both branes with mass-energy. The resulting energy density is large, but is not large enough to cause problems with the laws of physics. As the branes move apart, the matter and energy expands, the fundamental forces sort themselves out, matter and radiation form, nuclei are synthesized, radiation decouples from matter, stars and galaxies form and cycle through supernova explosions, planets coalesce, life forms and evolves, and so, here we are.

In the Steinhardt-Turok cosmology, the field responsible for the forces between the branes is a form of energy that permeates the space of the branes, so dark energy and accelerated expansion are direct consequences of the model. The Steinhardt-Turok Universe expands at an ever-increasing rate under the influence of the dark energy, and as it does, the average mass-energy density drops. Black holes that have formed during the high-density era decay into photons and electrons by Hawking radiation, and perhaps protons and nuclei eventually decay to the same final products. Ultimately, mass-energy in the cold and ancient Universe reaches the level of less than one particle per horizon, and the Universe is a cold, dark, dead, and empty place.

Then, in the Steinhardt-Turok model, a remarkable thing happens. The restoring force between the branes becomes dominant, and the branes begin to move together again. One might think that this would make space on the brane recontract in a time-reverse of the expansion, but it does not. Instead, the space remains cold and empty, but the coupling constants of the fundamental forces, which had been constant since the Big Clap, begin to change and become stronger. An observer would experience some fairly weird physics during the collapse phase as the forces change, but the Universe is empty and so nobody notices. Finally, the branes clap together again, filling the almost empty branes with a flood of new mass-energy, and the cycle repeats.

That's the model. And remarkably, it can probably be tested against the standard Big Bang model in the next decade. The Big Bang model, as a result of its turbulent super-high-density initial phase, should produce in its early stages a cosmic flood of gravitational radiation, and this should show up as polarization of the electromagnetic cosmic background radiation. The Steinhardt-Turok model predicts no such gravity waves and polarization. If that polarization of the microwave background is found, the Big Bang model gains strong experimental support. On the other hand, if no such

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polarization is present, the Steinhardt-Turok cyclic model receives similar support. The crucial measurements should be accomplished with space- or balloon-based instruments in the next decade.

Since this is a science-fiction magazine, let's consider some of the SF implications of this new cosmology. My friend, the late (and deeply missed) Poul Anderson, wrote *Tau Zero*, a marvelous hard-SF novel set aboard a runaway spaceship that accelerates ever faster, edging so close to the speed of light that relativistic time dilation permits the crew to view and experience the expansion, reversal, and recollapse of a Tolman-type cyclic Universe. They ultimately pass through the climactic Big Crunch and emerge in a brand new Universe, in which they are to become the Elder Race. Assuming the ship technology could be worked out, would that scenario be possible in a Steinhardt-Turok Universe?

I'm afraid not. Up to the recollapse, things might work about as described in *Tau Zero*. However, no human observer could survive the era when the force coupling constants begin to change. The atomic and nuclear physics implicit in the chemistry of life works only because of a delicate choreography that precisely balances the strengths of the forces. A slight shift in this balance, and human (or nonhuman) observers would die from a variety of system failures.

The key concept used in Paul Preuss' hard-SF novel *Re-Entry* is that a spaceship hyperdrive that appears to provide faster-than-light travel (and even time travel) is actually transporting the ship from one cycle of a cyclic Universe to the next, but arriving at identical space-time locations that could not be reached by sub-lightspeed travel.

Preuss' delightful notion, while requiring a fully deterministic Universe, is a lovely solution to the paradoxes of faster-than light travel and time travel, and it fits well with the Steinhardt-Turok Universe. However, I think its requirement that each Universe cycle produces exactly the same worlds, down to the same individual humans thinking exactly the same thoughts, is a show-stopper. The intrinsic randomness that permeates the quantum level of physics guarantees that each cycle of a Steinhardt-Turok Universe will be very different than the others. Score one for variety.

So the field is wide open for new hard SF based on the Steinhardt-Turok Universe. Any takers?■

AV Columns On-line: Electronic reprints of over 100 "The Alternate View" columns by John G. Cramer, previously published in *Analog*, are available on-line at: http://www.npl.washington.edu/av. Preprints of most of the references are available at http://arxiv.org/ .

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Only he who has seen better days, and lives to see better days again, knows their value.

—Mark Twain

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Counterspy

Richard Foss

Bad news, Boss.

We have been working on that project to spy on the Third-planeters like you ordered, using the raw material you suggested—the cats. We were originally set on using dogs because most of them are bigger and we wouldn't have to miniaturize the transmitters as much, but we decided you were right. The transmitter implant worked great on our test dog, but every time it followed Third-planeters from room to room to track a conversation, they put it outside. There was also a problem with mimicking customary behavior when the subject was under our control. To give just one example, Third-planeters would throw objects and then stare expectantly at our spies. It turned out that they expected our spies to go get them and bring them back, but we still haven't figured out why.

The cats are smaller, which gave our transmitter designers fits for a long time, but while our technicians were wrestling with the problem, we observed Third-planeter/cat relations and they seemed to be greatly to our benefit. Third-planeters don't seem to expect cats to obey orders, and aren't surprised at nearly anything one does. One of our early implant units had a major breakdown and the cat we were controlling went running all over one of their domiciles, chasing nothing and making horrible noises. Not one of the Third-planeters thought that was unusual. That should have made us suspicious, but it didn't.

Anyway, the designers finally made a breakthrough, and created an organic transmitter that was capable of controlling the animal while making use of most of its sensory data. We settled for eyes and ears. We could have added smell and touch, but the unit would have been too bulky. The unit was to be powered from the cat nervous system, and our designers managed to minimize it to a cluster of just one hundred cells,

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set in a spot right at the base of the brain. That's right—one hundred. The best minds on our home planet hadn't been able to do it with less than three hundred before this. It required a different implant location than the older models, so it was trickier for the surgery department, but we were sure it was worth it.

We went to implant the first of the improved models, and that's where the bad news comes in. There was already one there, and not with a hundred cells. Fifty, that's all it took them, arranged in a double helix. Somebody else is already here and spying on them too. These cats act like they're from another world because they are.

Bad news, all bad news. Before we knew about the other transmitter, we took some cats to our base so the transmitter implanters could work on them, and they're not behaving like they did down on Third-planet. They're watching every move we make, and from the way they pay attention I'm afraid they're decoding our speech. My team are writing notes to communicate to each other, but I'm afraid it's too late. They've seen us without our disguises.

We're busted, Boss. But I don't know by who.■

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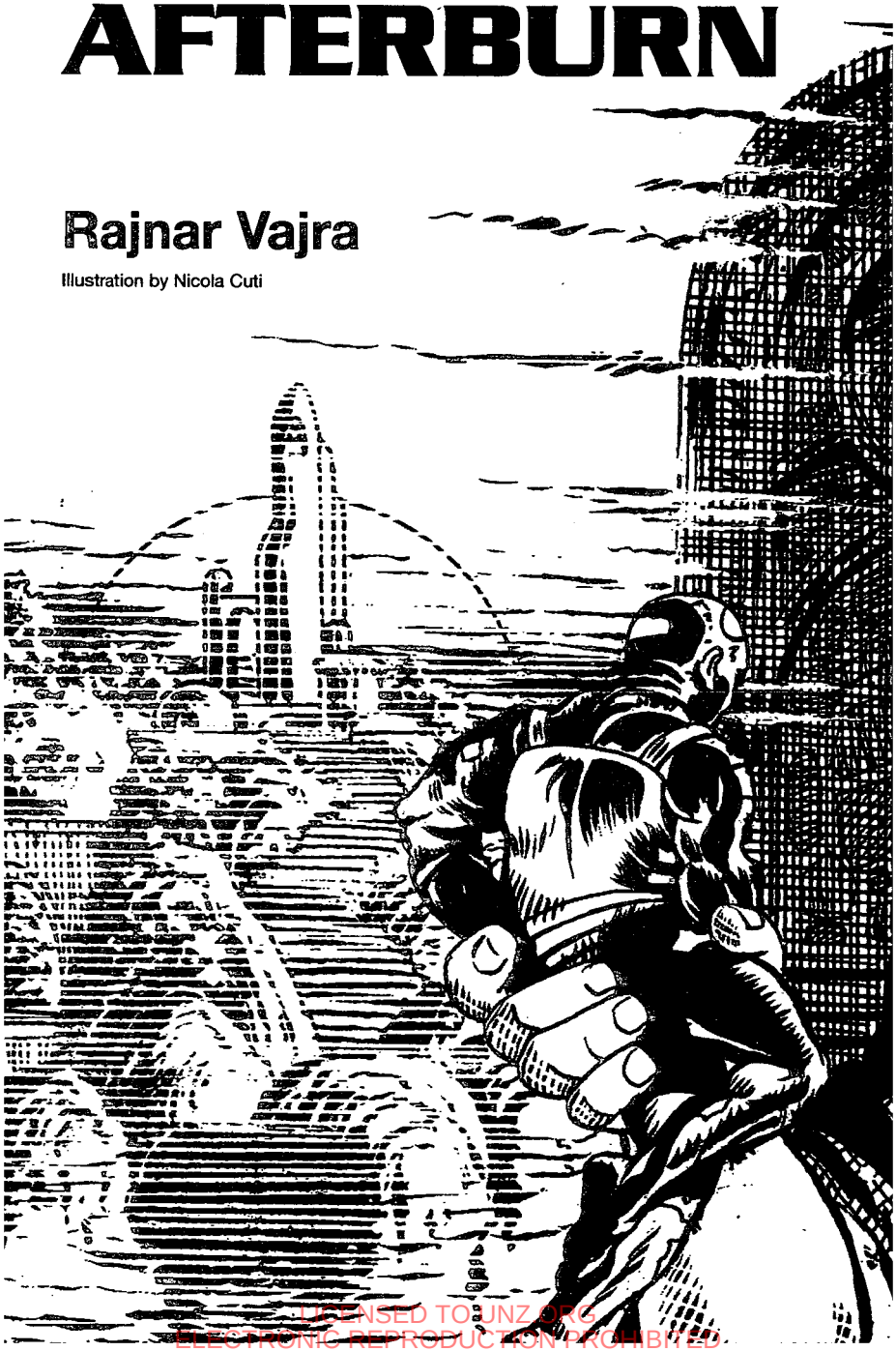
Problems are relative. As the saying goes, "Consider the alternative. . . ."

AFTERBURN

Rajnar Vajra

Illustration by Nicola Cuti



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Paul

I jump into a small black boat. Perhaps it's made of wood. I can't tell if I'm sitting or standing. I see no oars. The boat autonomously leaves its dock and floats away on the grim turquoise river, following some dark agenda rather than any natural current. I am bone marrow weary but it could be suicidal to relax. There may be enemies nearby. I don't see any, but that doesn't mean a thing.

I am too exposed now, too far from the sandy riverbanks, gliding though this underground purgatory lit only by Ferrari-size torches that burn red, blue, or green. I need those torches, but God, how I hate them! Drusy stalactites catch their light, blend it, and hurl it into my face like a mortal insult from rainbows. My sore eyes are constantly whipped with glints and streaks. And in this place, above all, I need good vision.

I admit that these endless caves are impressive. Tall enough for clouds to form and rain or snow to fall. Right now, the stony skies are clear but that could change in an instant. Everything can change in an instant.

The boat lacks a tiller, but I get a sudden sense that my right hand is gripping something invisible that provides me a measure of directional control, something alien to this world but obscurely related to it. I've had this sensation before, always mingled with irrational bittersweet nostalgia. But as a rule, I can't feel my hands. So I can't explain how one fearsome weapon or another so consistently hovers nearby, ready for another desperate use, as if I were holding it in front of me. And I can't explain how I manage to change weapons at will, or aim and fire them.

Very rarely, the entire world unaccountably *thins* and I can dimly see my arms. That is, I think they are mine. Those are terrible moments because there is something terribly wrong with those arms. And when I glimpse my hands or seem to glimpse them, I dare not count fingers because so many are missing. The left hand is the worst—red, black, white, and shriveled—adorned with shiny yellow, unnatural growths.

But I am too afraid for my life to worry for long about anything else. Enemies can come from anywhere, and from any direction including beneath and, in one horrid instance, from within.

Sue Williams and Carla Carroll

"I've seen something like this before," Sue remarked in a voice more suitable for a library or funeral.

A thin line appeared between Carla's gray eyebrows. "I'd assume so."

Sue flushed. The hardest thing about transferring to a new hospital was the way even her fellow physicians would take one look at her and commence the usual assumptions. "I'm not talking about *aquariums*, Doctor. I've seen tanks much like this intended for people."

The pale eyebrows compressed then sprang up. "You have? Where?"

"In movies. On—" Sue grimaced slightly "—on TV. It's a surprisingly common theme. Maybe that's what gave him the idea."

The older woman tried to brush her annoyance aside. Newcomers always had idiosyncratic reactions to Unit Seventeen and the leaking subsonics didn't help. "Well, this one is real. And so far, I daresay, unique."

"You mean there aren't sixteen others?"

Carla stared at her trainee for a moment, surprised. The question was clearly intended as a joke. Unit Seventeen had been named as such because basement-room seventeen was the only large space that the hospital could make available for the experiment. Until this moment, the younger woman had seemed too stiff to appreciate jokes, let alone crack one.

Sue placed a finger tentatively against the warm tank. "Such thick glass! And with all that liquid, I'd think the system

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must be incredibly heavy."

"Actually, your 'glass' is plastic. But you're right. Neoperflubron, even with softening agents and scar inhibitors added, weighs almost twice as much as water liter for liter. Unit Seventeen, including all its . . . contents, weighs over four tons."

Susan braced herself to look past the ghostly reflections of the room's many ready lights and stare again into the heart of the tank, but her eyes kept sliding away. She mumbled something very quietly.

"What's that?" Carla asked.

Susan was embarrassed to realize she'd spoken aloud. "Sorry. I was just thinking that the *Chronicle* once called him 'the most eligible bachelor in San Francisco.'"

Paul

I see what is undoubtedly my next destination, a narrow island that bifurcates the river perhaps a half mile ahead. A very tall structure looms on that island. It could be a castle or a bizarre skyscraper, or something new and outlandish. I can't tell from here because it is sheathed in mist. But I don't like the looks of it.

My boat accelerates as it approaches the island and I think, for one naive instant, that there won't be any trouble until I set foot on dry land. But a new kind of enemy appears. There are two of them high in the air, both behind me. They look like inflated wasps or grotesquely painted, segmented balloons. They lack wings but fly effortlessly. They have thin, insect arms ending in huge lobster claws. One opens its mouth and something darts out.

I am frozen with terror because it seems to be spitting fire at me. That, I can't have! But, no. It isn't fire headed my way, only a knife, spinning, catching the relentless torchlight.

Fine. My current weapon is a rocket-launcher. I aim it at one enemy and quickly release two rockets. Then I dodge the knife by moving a step to the left, being careful to avoid falling out of the boat. I have learned to distrust these waters.

My rockets are swift, but the first enemy avoids them both and spits forth three more knives. The second enemy belches forth two daggers of its own. I am in serious trouble. Again.

Sue Williams and Troy Dane

Troy strode into the room quickly for such a heavy man, studied the readouts, and then visibly relaxed before turning toward Sue. "Doctor Williams? I'm Troy Dane."

Sue tried to look professional and intelligent, but was certain it was a lost cause. She'd recognized the familiar sequence of surprise, recognition, and then swift judgment on Troy's broad face. Once again, she'd been weighed on the scales of her notoriety and found wanting. This time, at least, the typical signs of sexual curiosity were absent. Perhaps the man was in love . . . or gay.

She took a breath, determined to at least *sound* competent. "Sorry to call you down, Doctor, but there was some sudden heavy brain activity and his adrenaline, cortisol, and norepinephrine rose sharply. Neuropeptides are still miles above his baseline."

"And?"

The noncommittal response flustered Sue a bit. "I wouldn't have bothered you, but Doctor Carroll, who's been training me on this equipment, isn't answering her beeper."

Troy smiled reassuringly and instinctively lifted a massive arm to pat Sue on the shoulder, then reconsidered when he saw her start to flinch. He lowered the arm awkwardly. "Carla's probably sleeping like a baby; she hasn't had much rest since your, ah, predecessor quit. I'm sure she explained to you the pain-reduction system we're using here." He didn't sound sure.

"More or less." Sue interpreted this as

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a test and resolved grimly to pass with honors. "As I understand it, the electromagnetic fields that provide alignment and stimulation to his new cell-scaffolds are also being applied to his brain, generating random stimuli, blocking out both pain-signals and hypothalamic wake-up calls."

Troy opened his mouth then closed it without saying anything.

Sue didn't notice. "And four to six times an hour, a strong forty-cycle pulse is applied to his entire reticular formation, sending him into intense dream states."

"True enough. But you've left off something. As you probably know, we're trying to keep him, um, somewhat *afraid* in there." Troy aimed a thumb toward the tank. "Loud, low-frequency sound is the ticket. It was his idea that organisms might heal faster if they feel threatened. The theory is unproven, to say the least, but since he can only stay in there for such a limited time . . ."

"It's worth trying something radical that might speed up his regeneration. I do understand. But according to these readouts, he's not in one of the peak stimulation phases at the moment."

Troy's chin lifted. "Now I get you! We don't know why or how, but he's recently taken to, uh, instigating some *internal* stimulation on occasion. At first, we were alarmed. But it didn't seem to do him any lasting harm and perhaps it's even led to some small acceleration in the, um, process."

Susan nodded stiffly. "Doctor Carroll mentioned that, but she didn't say that the readings would get this high. I don't want to overreact, but I was taught to choose safe over sorry." Christ, she thought, when did I start talking like such a pompous ass?

Troy glanced at her speculatively. "Safe over sorry? You're right, of course, but I'm afraid that, uh, pioneers are seldom safe and often sorry. This is all . . . terra incognita. But I'd like you to answer a question and please be absolutely honest: how are you feeling at this very moment?"

"Well, somewhat . . . on edge, to tell the truth. It's probably my imagination, but I keep feeling like something's about to go—" Susan frowned as she hesitated, "—horribly wrong."

"Aha! That's our subsonics at work. They'll ruin a good mood every time. We've tried to confine the vibration to the tank with phase-canceling speakers built into the walls here, but the system isn't perfect. I'm used to this place, but just standing here, I always get this feeling of impending doom."

"Is that so? Doctor Carroll warned me that the subsonics might make me 'just a tad jittery.'" She'd made quotation marks with brusque finger motions.

Dane shifted his weight and smiled unconvincingly. "She probably didn't want you getting nervous about getting nervous."

"What makes me nervous is when people don't trust me. But why do we need the subsonics running *continually?*"

The big man's smile became more genuine. "Good question! We've tried shutting them off several times. Each time, the patient became nearly comatose and his metabolism slowed accordingly. If you want my intuitive opinion, I think he was right. I think that fear is his best friend."

"Then wouldn't it be possible to monitor all this from another room?"

"Well, we thought of that, certainly. But it's hard to see the, um, subtleties of his behavior over a video monitor. Those little twitches can be significant. And, as I'm sure you were told, on occasion we have to make instant decisions and adjustments. That's why we need a trained expert standing by at all times." Troy glanced at his watch.

"Thank you, Doctor," Sue said quietly. "You've been very helpful. I'll try not to bother you again."

"Don't hesitate to call if you need me. And don't expect too much from your-

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self. There's a reason why we have a high turnover on this job."

Paul

By alternately crouching, dodging, and jumping, I elude three salvos of knives. One blade I see just an instant too late. It comes in spinning too fast to stick, but hits hard enough to pierce my armor. A sickening pain blossoms between my left shoulder and left nipple. I don't know how bad I'm hurt; I can't see or touch my chest. The pain is severe, but not nearly as bad as my initial injuries in this place. The first time I was stabbed, I blacked out. I've never understood why the creature who stabbed me didn't finish me off. The latest monsters are getting harder and harder to kill but their abuse seems progressively less agonizing.

I hurriedly switch weapons, selecting one I think might work best against the bloated wasps: an energy-beam emitter whose disadvantage is that the beam fizzles out after two seconds, rendering the emitter useless for hours. I only dare to use it in an emergency, but this certainly qualifies.

My aim has been improving steadily and before the weapon fails, both my attackers are shredded, their dismembered body-parts bobbing in the river, which bubbles white everywhere flesh has fallen. I try not to dwell on why the water is bubbling, or how much my chest hurts, or on how much blood I must be losing. Dwelling on trouble always makes it worse. The secret is to just keep going, and before too long, all injuries will be forgotten. I have no idea why this happens, but I have no time to ponder mysteries.

The structure on the island seems to be an ancient ruined cathedral. Its granite outer walls are cracked and its roof had, at one point, apparently exploded upwards, leaving only twisted metal beams that nearly scrape the limestone ceiling so high above. The building is immense enough for gods to assemble and worship each other. The polished marble doors, a good hundred feet high, swing open soundlessly as I approach. Getting into buildings is rarely this easy. But as I accept the invitation and step inside, the doors swing closed behind me and I hear the clank of a mighty lock snapping shut. In all likelihood, I will not be leaving this way, assuming I ever have the chance to leave.

The vestibule is long and dark, but with the wall-cracks and open roof, I can see another set of doors ahead. River sounds are absent here, replaced with ominously deep creaking and skirls of strange music. Someone may be playing a harmonium nearby, and many voices are producing something akin to Gregorian chanting. These out-of-tune voices are mostly so inhumanly low-pitched that I fervently hope to never run into the choir.

As I approach the new and far smaller doorway, the floor begins to glow, which makes the puzzle waiting for me at the vestibule's far end brightly visible. This puzzle is a purposeful arrangement of elements. Sitting atop a four-foot-tall marble pedestal is a small golden bowl filled with silver flames. Near it is a closed, wire-mesh cage on its own platform. There are three levers outside the cage. The cage has three separate divisions, each with its own basin, each basin filled with a different substance. A blue basin holds water, a yellow one holds dark sand, and the last is a silver basin with golden flames.

To be methodical, I try the inner doors; but as I expect, they don't budge. Clearly, I'll have to solve the puzzle to get further inside the cathedral. Good. Monsters have never attacked me whenever a logic problem has arisen. And I desperately need a respite.

I will my floating weapon to vanish and it obeys. But as I examine the apparatus, I worry. The puzzles have gotten increasingly harder and this one seems unsolvable.

The goal is obviously to quench the

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flames in the golden basin. Assuming this challenge follows the usual rules, one of the three other substances should do the trick. But there are trapdoors underneath the caged basins. Each lever is cleverly wired to open one third of the cage, and at the same time, to open the trapdoors in the other two sections. I'll have exactly one chance to guess which substance is a silver-fire extinguisher.

Not easy. Water or sand would work with a normal fire, but these flames aren't normal. They look like animated incandescent plumes of liquid mercury, slightly translucent near the tips. Magic flames. Perhaps golden flames cancel silver ones, perhaps not. Why should silver and gold be considered opposites? I can't afford a mistake.

I am uncomfortable. I abhor being close to any kind of fire. . . .

Carla Carroll and Troy Dane

"I met," Troy said hesitantly, "your latest protégé last night."

Carla raised her hands apologetically. "I know. Doctor Williams left a note on her watch-chart about it. It's really my fault, Troy. She's such a quick study that I probably covered too much material too fast and left out some important details. I'll try to fill in some gaps when she shows up for her afternoon shift."

"But she does know what to look for and how to handle the equipment?"

"Do you imagine," Carla growled, "I would have let her take a watch by herself if I wasn't convinced she was ready?"

Troy didn't move but somehow he seemed to take a step backwards. "Absolutely not! I didn't mean to imply any such thing!"

"Glad to hear it."

"Uh, how is she working out . . . generally? She isn't exactly your average doctor."

Carla studied Troy's face. It was as earnest, damp, and big as usual but she'd learned long ago that her department head had hidden depths, or perhaps hidden pockets was more apt. "Are you really asking, or did you notice something specific you wanted to bring to my attention?"

"Just asking. Well, mostly asking. She does seem just a little, um . . ."

"Defensive?"

"Something like that."

"Christ, Troy! The woman has a chip on her shoulder you could burn in your fireplace all night long. Price of fame, I imagine. But I'm really too busy to fret about it."

"It won't interfere with her work?"

"Why should it?" A low-oxygen warning chime sounded and Carla glanced toward the tank then casually made an adjustment on the zeolite adsorption regulator. "Do you ever wonder, Troy?"

"Wonder about what?"

"What he's going through in there?"

"No more than a thousand times a day. He told me, before the accident, that everyone subjected to the stimulation would have a different experience. He tried out that part of the system himself. Outside the tank, of course."

"Did he ever describe *his* experience?"

"He dreamt that he was playing a computer game he was obsessed with when he was a kid. But under stimulation, he'd believe the adventure was real. He made it sound like fun. But sometimes when I'm here, I feel like I'm watching someone who can't wake up, who's having the . . . worst nightmare of all time."

Paul

No matter how hard I try, I cannot find a logical solution to the puzzle. The solution only dawns on me when I ask myself a nasty question: what will I do if there is no solution? My only option will be to choose one of the three substances at random and take my chances. That thought brings me to the next. In order to use any of the substances, I'll

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need to move it over to the silver flames. This implies that I'll be able to pick it up! In this world, I've rarely had the power to carry physical objects.

I must have that power now. Therefore, I can turn the problem on its head.

Reluctantly, I move closer to the golden bowl and imagine myself lifting it off its pedestal. I cannot feel my arms, but the bowl rises smoothly into the air and stays with me as I approach the cage. I am very uneasy. I reach the cage and imagine the bowl tilting. It tilts, pouring a single drop of quicksilver flame into the water-filled basin. The drop sinks like a lead pellet, burning fiercely and unquenchably at the deepest part of the basin. The next drop goes into the black sand and lies there, still burning.

I don't bother experimenting with the golden flames, but hastily upend the entire bowl of silver fire over them. The bowl vanishes and the result surprises me. Neither fire is extinguished. Instead, the flames combine, becoming something greater and brighter than mere silver and gold. Call me an unintentional alchemist! What I have made was once called "electrum": gold and silver in perfect balance. The door to the inner part of the cathedral gapes wide and the eerie music becomes frighteningly loud. It seems I am doomed to encounter the subwoofer choir after all. Yet I am also vastly relieved. I was afraid the two beads of pure silver fire still burning might be enough to keep me trapped.

When I call forth a weapon and step cautiously through the door, I am awestruck by the sheer size and majesty of the astonishing being who awaits me in the heart of the cathedral.

Dana Huang and Sue Williams

"I see you've been with us for a month now," Dana remarked mildly, her eyes trained on some notes she'd taken during a recent meeting with Carla Carroll. Dana was privately amused at her own strong impulse to ask Sue Williams for her autograph.

"Only a month?" Sue thought for a second and shook her head ruefully. "You're right. I started on the nineteenth so it's been exactly a month."

"Doctor Carroll tells me you're doing extraordinarily well, that you have a real knack for anticipating your patient's needs."

"I'm glad Doctor Carroll approves, but having only one patient simplifies things."

"Is that all there is to it?"

Sue's eyes narrowed. "Perhaps not. The job seems to keep getting easier every day. In a way, I identify with him."

That last remark was a waving red flag, but Dana carefully kept her expression neutral. "I bet you're wondering why I called you in."

"Clearly, you're an excellent psychologist, Ms. Huang." Sue was smiling faintly now.

Without lifting her head, gazing over the rims of her reading glasses, Dana studied the doctor with what appeared to be friendly interest. "I try my best. Our interview today is just routine hospital policy. We like to check with our staff now and then and see if there's any way we can make your lives easier." This was a quarter-truth at best. New employees were usually interviewed after six months, and then annually. But Troy Dane had expressed concerns. And Doctor Susan Blake Williams was a most unusual employee. . . .

"You want to improve my life?" Sue's smile was more pronounced. "Then I'd like to order shorter working hours and more holidays."

The renowned smile was infectious and Dana caught it. "We'll get right on that. Meanwhile," she kept her voice light and unconcerned, "what did you mean about identifying with your patient?"

"Well, it's just that he's so . . . isolated."

"Because he's inside a tank?"

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"That, too. But what I meant was that he's become so different from everyone else."

Dana leaned forward and her eyes sparkled with interest. "Physically different?"

"Partly. He's so . . . on display. And even if the new techniques—and isn't it incredible that *he's* part of the team who developed them?—even if they work as well as we all hope, he'll never really look quite right."

"He won't?" Suddenly the emotional problems of this rich and beautiful woman sitting in front of Dana seemed trivial. "Why not?"

"We can only speed up the replacement growth so much."

"Oh. Oh my! I suppose I knew that, but I hadn't looked at the implications. So, at best, for the next few years he'll be a middle-aged man with—"

"The fingers, toes, ears, and nose of a six-year-old. Among other disparities."

Dana took off her glasses, folded them, and laid them carefully on her desk. "But the new parts will keep aging at an accelerated rate and eventually catch up?"

"If only! Once he leaves the tank, all his . . . parts will age normally."

"Can't he simply stay in the tank longer, then?"

"I'm afraid not. Electro-stimulation provides the only exercise he's been getting for almost two months. He's got to have weight-bearing exercise soon or his bones will decalcify, perhaps irreversibly. And once he leaves the tank, that's that. It won't do any good to return. His cells will have stabilized and our targeting medicines won't be able to distinguish between old growth and new growth."

"Goodness."

"The system wasn't intended primarily for adult patients. But maybe I'm making his situation sound worse than it is. In ten years or so, he'll be proportionate again. But he'll always look like something Frankenstein put together in his spare time."

"How unfortunate!"

"I agree, but it beats the alternative."

Paul

Without my command, my rocket-launcher vanishes as I approach the titanic female figure. Just as well. I've encountered giants in this world on occasion; each time my best weapons were pitifully ineffective and I only survived by fleeing. This being is at least sixty feet tall, which makes the previous giants seem comparatively small and frail. I will run like hell if she attacks, although I see no place to run to. But I am not afraid, no more than usual. My heart tells me that she will not prove hostile.

How did she get into this part of the cathedral? I see no door other than the small one I passed through. Perhaps she squeezed in through the broken roof. The sound I thought was a harmonium is apparently air whistling through gaps in her teeth. The bass choir is just her, singing. Not Gregorian chanting after all, but childish rhymes. The wheels on the bus go round and round. . . . The fundamental frequency of her voice must be so fantastically deep that what I'm hearing are a series of harmonics, still mostly in the low-bass range.

But the strangest part is that this titan among giants is somehow familiar. If you ignore scale, she is shaped like a little girl. And her enormous face is terribly young. She looks no older than seven or eight. It seems to me I've seen that face before, wearing a very different expression. I don't know why, but I feel sad. The memory is no more precise and graspable than a distant nebula. . . .

She sees me, smiles, and hunkers down to place her hand, palm up, on the polished marble cathedral floor. I obey the implied command, climbing up and standing on her open palm. She stands straight, effortlessly lifting me forty feet off the ground. She looks down upon me, still smiling, but a single

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tear falls from a watermelon-size eye and bathes me in a salty shower.

I am renewed! Weeks of exhaustion and fear are washed away! For one disorienting moment, I feel the textures of a computer controller—an old-fashioned trackball—under my right hand, my thumb resting on the smooth wheel. Then the trackball softens, evaporates, and I can see my arms.

They've evolved since I last glimpsed them. They are still horribly mutilated, but the skin is pink and hale. What were once melted stubs are now midget fingers, three on one hand and two on the other, keeping the full-sized ones company. I can wiggle the entire ten-piece collection. I stare at the glossy yellow tubes, catheters, and sensors attached to my arms and feel an unaccountable burst of pride. It's working! Then the vision fades along with pride.

Suddenly, I realize that the goddess—what else could she be?—is addressing me! It's hard to understand her because she sounds like dozens of deep, strange voices speaking an unearthly tongue. My ear adjusts. I am hearing ordinary English, spoken with a childish lisp. But there is nothing childish about what the goddess is saying.

"Can you comprehend me now, Paul?"

"Yes." My own voice sounds absurdly high and squeaky.

"Then I offer you congratulations. You are now approaching the final levels."

"Final levels?"

"These are the conscious levels and if you wish to attain them you can only do so consciously."

Abruptly, I am deeply fearful, I don't know why. "What do you mean?"

She moves her face closer to mine and I realize with an unpleasant shock that her forehead has a skin-graft tautness. "You have decisions to make."

I have to swallow twice before I can get my voice to work. "What decisions?"

Her left eye—huge, clear, and innocent—becomes liquid with another goddess-sized tear. But this time as the tear falls, it falls as a flat sheet rather than a drop and freezes in midair. It lengthens, becoming progressively more reflective as it expands, until I am facing a perfect rectangular mirror. I can see the cathedral behind me. Thin colored beams of light are streaming through the open roof, poking crepuscular holes in the mist, spotlighting mysterious icons and altars to unrecognizable deities. But, vampirelike, my body isn't visible.

"I offer you," she says in her many voices, "the middle past."

A tall lanky man with indifferent posture appears slowly in the mirror like a developing photograph. His head is crowned with an unruly thatch of black hair, silvering at the temples; a gold-plated stethoscope hangs from his neck.

"Do you recognize this man?"

In a way I do. I recognize the face, but what I'm seeing is an upsetting and unfamiliar version of me, a civilian version. I have had glimpses of myself recently, in night-dark ponds and crystal windows, and those glimpses revealed a potent warrior, massive yet sleek, sheathed in bronze muscle and burnished armor. This man is puny and pale. He looks like a person who has lived his life resting in a velvet box. And he has no weapons . . . although I suppose the stethoscope might be used as a garotte in an emergency. . . .

"Surely, this isn't supposed to be me?" I ask, angrily.

"This is as you were in the middle past." The great voices sound oddly sympathetic. "Now, I offer you the recent past."

The figure fades and what replaces it is so hideous that I turn away from the sight, fall to my knees on the goddess's rock-steady palm, and can do no more than simply breathe for a few minutes.

Yet the image has imprinted itself—I almost dare the word "burned"—into my memory. I see it with my eyes closed.

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"I am sorry, but this you must face." The goddess speaks gently.

"I can't." Despite my denial, I'm already struggling to my feet and opening my eyes.

The unfortunate person in the mirror has been half-melted in some dreadful blaze. I cannot tell if it's a man or a woman. Many fingers and toes are gone along with the hair, ears, nose, genitals, and considerable skin. One eye is a scorched socket. The skin that remains is either charcoal-black or has the white blistering of third-degree burns. I know from bitter experience that this victim will not live for long. Unless . . .

"This isn't me again, is it?" I am shamed; no warrior should use such a fragile voice. Besides, I already know the answer.

"It *was* you. Now, I offer you the near future. Do you have the courage to see it?"

Sue Williams and Carla Carroll

A brass sign on the door was lettered "Dr. Paul R. Levine."

"I'm not comfortable about this," complained Carla, placing a key in the lock and twisting it a bit harder than necessary. "But Dana Huang approved your little expedition."

Sue frowned at Carla's back as she followed the older woman through the doorway. "I'm not planning to snoop through his belongings, if that's your concern. I'm just hoping that by spending a few minutes in his office I'll get a better feeling for who the man is. Besides, this is partly your doing."

Carla flipped a light switch and whirled around. "My doing?"

"In a sense. You're the one who assigned me to keep working with Doctor Levine, even after he leaves the tank. And you're the one who told me that his office was more . . . personal than most."

"I suppose," said Carla slowly, "you have a point. At any rate, here we are. And I've very little spare time today, so I'd appreciate it if you could get this done quickly. If you've got questions, I'll try to answer them."

A tall window provided an attractive view of the verdant Marin hills along with a slice of the Golden Gate. Ten separate piles of paper were lined up on a large oak desk, trapped neatly beneath ten fumed-glass paperweights. One desk corner was dedicated to a grouping of color photographs in silver or wooden frames. Sue went behind the desk, sat down self-consciously in an Aeron chair a size too large for her and studied the pictures. Despite the hospital's air-cleaning system, the exposed surfaces were coated with a film of dust, which seemed thicker atop the picture frames. "I wonder if these are his parents or his grandparents?" she asked, pointing to a photo because she was reluctant to disturb the arrangement.

Carla walked around the desk to see. "Parents. Clay and Deborah Levine. Both deceased. Paul told me that Deborah was forty-eight when he was born."

"And this must be a brother?"

"Daniel, his only sibling. Five years older. Dan's a corporate lawyer who works for some insurance company in Connecticut. He's been here twice since the accident. You'll meet him before long, I'm sure."

Sue leaned forward to get a closer look at a picture in a particularly thick wooden frame. "Who's the little girl? She doesn't seem to resemble anyone else in the family."

"Mary Kandziolka." Carla's gruff voice had turned soft. "Not a relative. Twenty years ago, Mary was one of Paul's first patients during his residency in Burns and Trauma at San Francisco General. She changed his life. That picture was taken on her sixth birthday. A week later, she nearly died in a house-fire. I don't think Paul would mind if I . . ."

Carla lifted the frame, undid a small catch, and the frame opened to reveal a hollow space within, filled with more pictures. She carefully removed them

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and spread them out on the desk.

The first ones were hard to look at. The girl was unrecognizable, scorched from head to waist. Next, she appeared heavily bandaged. Subsequent photos showed her progressing through a long series of skin grafts and rebuilding operations, a painful process that must have taken years. The final picture was of a young woman, somewhere in her middle teens, who appeared almost undamaged . . . unless you looked closely.

"How did Mary Kandziolka change his life?"

"Paul was her primary physician through her entire process of reconstruction and rehabilitation." Carla sighed. "He became personally invested. Eventually, he couldn't stand the thought of any more children going through what she went through. As you know, we've made great strides in cosmetic surgery over the last two decades, but—"

"It isn't nearly enough."

The dour lines of Carla's face eased as she regarded the younger woman. She nodded approvingly and walked over to a ladder of steel shelving near the window, reached up to a high shelf, and pulled down a clipboard holding a sheaf of papers.

"You might find this particularly interesting, Doctor," she said, handing over the clipboard.

Sue stared at the topmost sheet. Rectangular boxes labeled with either a "P" or an "S" were scattered thickly over the page, connected with ruler-straight pencil lines. Inside each box, in lettering so tiny it would have been illegible if it weren't so precise, was a short paragraph.

Sue almost immediately realized that "P" stood for "problem," and "S" for "solution." Most solution boxes had new lines running to possible problems generated by the solution, and those problems, in turn, ran to their own possible solutions. Some solution boxes, such as one labeled "Nogo 66," contained a question mark.

"It's all here, isn't it?" said Sue, almost reverentially. She unclipped the papers and riffled through them. More boxes. Eyes still focused on the diagrams, she left the chair, walked around the desk to where there was enough room on the carpet, knelt down, and began arranging papers. Carla said nothing and merely watched.

It was a big mosaic; each paper was a tile and lines stretching from paper to paper made the positioning clear. Fully assembled, the chart was a paean to organization.

Sue traced some of the major patterns with a finger.

Problem—scar tissue forming too rapidly, inhibiting new growth. Solution—debriding. Problem—pain and inefficiency. Solution—tissue softening and scar-inhibiting agents. Problem—applying softening agents uniformly and continually . . .

Problem—lung damage from heat and smoke inhalation. Solution—liquid ventilation (perfluorooctyl bromide), (note: 0.2 micron emulsion small enough to force capillaries open). Problem—unsafe for long-term use (?) Problem—maintaining oxygen level, removing CO_2 buildup . . .

Problem—damaged soft tissue and nerves. Solution—inhibiting scar-tissue based anti-regenerators such as proteoglycan, creating new tissue scaffolding (fibrin matrices? hydrogel?), encouraging cell adhesion (Nogo-66? Steroids such as oxandrolone? Salasodine?) Problem—creating and aligning new tissue scaffolds . . .

Much of the chart was highly technical, but the array of lines eventually led to one modest box on the last paper, which held a brief description of Unit Seventeen, referred to as a "healing tank." What was so impressive to Sue was how thoroughly integrated this final solution was. Every aspect of the system, from its perfluorochemical emul-

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sion to the magnetic fields generated in the tank's supporting platform, did double or even triple duty. Dr. Levine apparently had a talent for engineering. Only one "problem" rectangle was attached to that penultimate box, and the rectangle held only one word: "funds." The chart was dated July 5, 2018.

"He had it all worked out six years ago," Sue said quietly. "Please tell me more about his accident."

Carla was looking out the window wistfully. "If we can get going, we can talk on the way."

"Of course," said the younger woman, gathering up the papers. "Thank you for giving me so much of your time. I've learned a lot here."

Carla waited until they had left the room and were halfway down the corridor before she said, "It happened on Nob Hill. Just blind bad luck, I suppose. For Paul, it was a matter of being in the wrong place at the worst possible time."

"He hit a truck?"

"Other way around. He was headed downhill on Powell when some idiot bicyclist swerved in front of him and he had to slam on his brakes. The police think the truck behind him was tailgating, but the driver claimed he couldn't stop in time because the street was too steep. The skid marks were 'inconclusive' and Powell *is* awfully steep near the top." Carla scowled. "Such is the fabric of lawsuits. But the results were indisputable. The truck rear-ended Paul's fancy sports car and the car's methane tank ruptured and exploded."

"It's amazing he survived."

"If the paramedics hadn't gotten there so fast, he wouldn't have. Even so, he would have certainly died within an hour if Unit Seventeen hadn't already been set up, ready for its first test with a human volunteer."

"Incredibly bad luck and then incredibly good luck."

"That's life," said Carla.

"The inventor becomes the first subject for his invention. That's how they'd script it on TV."

Carla shrugged. "Sometimes, clichés happen."

Paul

The image in the mirror re-forms. It has two good eyes. The black hair has returned, this time with no hint of gray. The body is naked. Its skin is pink, healthy, and whole without any telltale scarring or seaming from skin grafts. But the restored features are bizarre, anachronistic. The nose is a stub and the ears absurdly small. Most of the fingers and toes, along with the penis and scrotum, match the size and apparent youth of the nose and ears.

Nevertheless, I recognize myself. The miniature features make my head seem swollen, grotesque. I look like a juvenile conception of a Martian. The effect is chilling. Unacceptable.

"Now that you have seen the near future," the goddess says, "are you willing to live it?"

"Do I have a choice?"

"Always. Either you accept what life offers with a whole heart or you struggle futilely against it."

"What difference does it make?" I sounded as bitter as cyanide.

"All the difference between being asleep and being awake."

The statement seems nonsensical at first, a complete non sequitur. Then it hits me. She is talking about living in the world *as it is* rather than as I wish it was. An electric shock of insight galvanizes my soul. I feel like a sock that has suddenly been turned inside out . . .

What kind of problem is it to look like a freak compared to being that half-incinerated hulk I'd seen in the mirror a minute ago? When had I developed so much vanity connected with my appearance?

I smile because all my silliness has been exposed, and the humbling fresh air is an unexpected relief. What a fool I am! All my life I've been coddled, insulated from difficulties. Coddled by a

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well-to-do family, high social standing, connections that made it easy to get into medical school, coddled by the twin accidents of being smart and reasonably good looking. God, in so many ways I'd had it so easy! And now, for the first time, I lose my immunity to personal unpleasantness and stand face-to-face with my own unconscious arrogance, an arrogance born and nurtured by privilege.

And I know where I am now; at least I think I do. I am asleep in my own healing tank! Was I burned in a fire? I don't remember, but I must have been. Therefore, all this is only a dream. But it is my dream and here I have become both teacher and student.

"Welcome to the final levels," the goddess says quietly in her multiple voices. She kneels quickly and I jump off her hand to the floor. She stands again but she shrinks while I grow. For an instant, we are exactly the same height and gaze directly into each other's eyes. Now she is child-sized while I am a giant. She is becoming transparent along with the cathedral itself. She waves and vanishes.

I am floating in a vast empty ocean. I think I am alone, so I am startled when I hear her voice again—sweetly and appropriately pitched for a girl of eight—coming from the center of my chest.

"In many ways, you are immersed in your own salvation, Paul. But how many others can you save?"

This time, I understand her immediately. The problem I'd been attempting to address, suffering and disfigurement from severe burns, is far more common than most people realize. But my solution had been shaped partly by my long-standing separation from life's realities. I'd set up an absurdly exclusive health spa. Unit Seventeen was effective, that much was obvious, but the system was fantastically expensive, care-intensive, and limited to one person at a time. I'd been so focused on building the perfect regeneration tank that I hadn't even considered how impractical it would be to set up similar systems in other hospitals!

I could do better, much better, and I would. For starters, it should be possible to build tanks that could hold four or five patients at once . . .

Something has changed. That sense of foreboding, which has been with me for so long, is gone. Am I awake? I can see the tank around me! The walls show my own reflection, but the lighting is such that I can look past it and through the glass. There are three people in the room outside my tank. I know two, Carla Carroll and Troy Dane. But when I see the third, I decide that I am not completely awake yet, but standing in that damp sand between the ocean of dreams and the dry beach of conscious awareness. I recognize Susan Blake Williams even through her face seems more mature than it looks on all those TV shows of hers still in syndication.

Then I remember, years ago, watching an interview with Sue Williams when she shocked the entertainment world by announcing she was quitting show business. She was tired of "living on good looks" and wanted to do something worthwhile with the balance of her life. She'd claimed she intended to become a doctor, but the interviewer hadn't seemed to take her seriously.

So, it really could be Susan Blake Williams out there, but I doubt it. If she is only a dream-figment, my message to myself is banal but damn important: looks aren't everything.

Troy is pressed close to the side of the tank, holding a microphone. "How are you feeling, Paul? We'll be pulling you out of there after we run some final tests." His words resonate around me like bubbles of meaning.

Dream or not, I give a thumbs-up gesture and try to say, "The operation was a complete success, and the doctor lived!" My voice is a weird, deep buzz but it can't penetrate the tank in any case. Sue Williams is grinning. Perhaps dream-actresses can read lips.■

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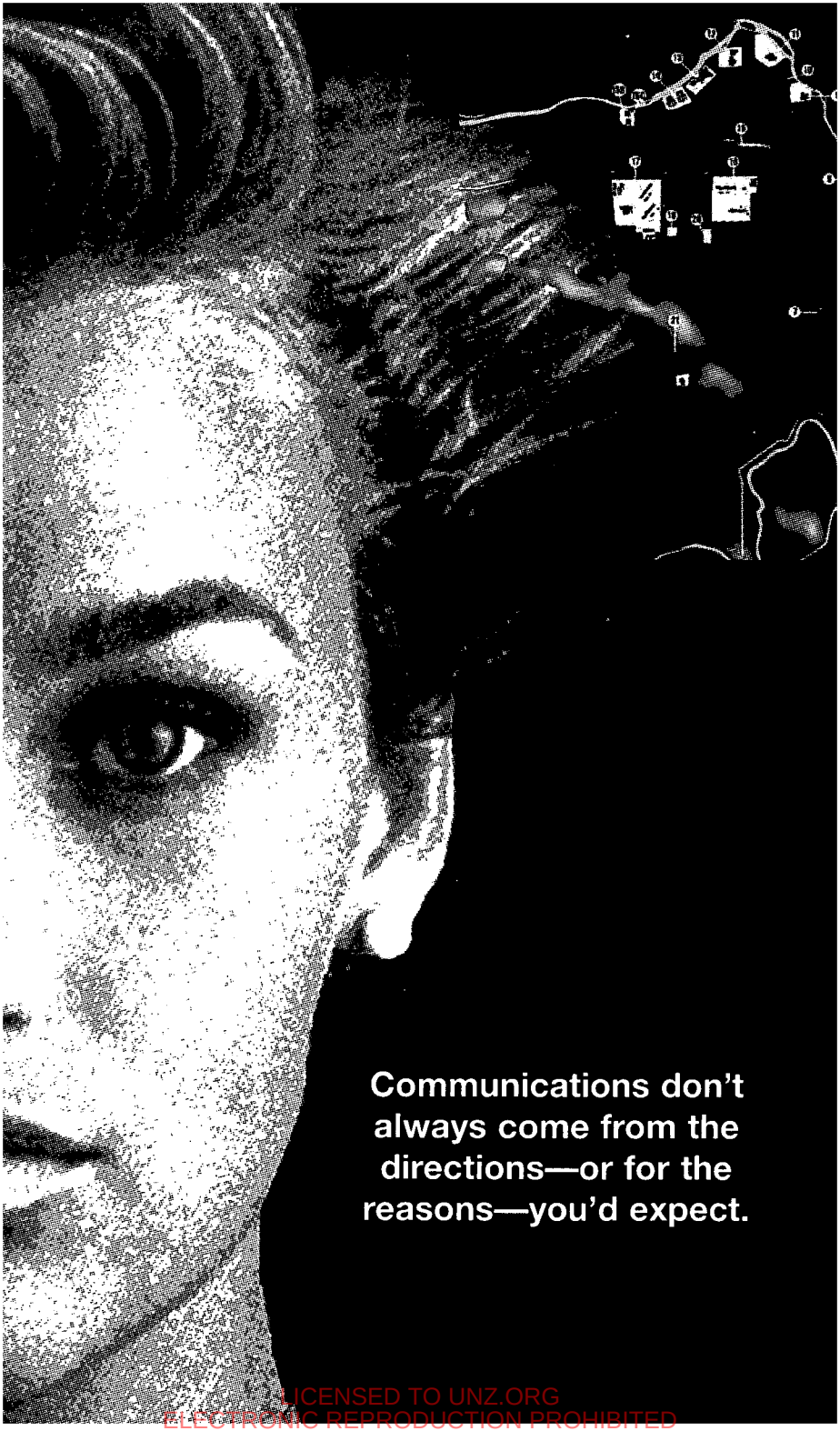

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Mixed Signals

Lori Ann White

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[redacted]ded to a stop at the far end of the LIGO parking lot, his gaze drawn toward the southern horizon. That way, past nuclear reactors, tumbleweeds, and the scrubby sagebrush desert of the Hanford Nuclear Reservation, lay his tiny Kennewick apartment and the promise of a quiet weekend. Cars full of Hanford workers zipped by on Route 10 in what the local wags called the Hanford 500—the daily race home. He could still make a break for it—

"Alex!" Professor Weiner shouted again. "The noise is back!"

Alex dropped his chin to his chest. Around him the serene summer evening suddenly came alive with the thrum of ceaseless vibrations. Passing cars rumbled like tanks, their wheels sending shock waves through the pavement. Behind him in the buildings of LIGO—the Laser Interferometer Gravitational Wave Observatory—electronics hummed, heating and cooling systems shuddered and clanked, the steps of his coworkers thudded against carpeted floors. Even the rich, golden evening light gave birth to vibrations; the earth groaned and flexed under its lazy strokes, warm air molecules buzzed about on the breeze.

And each vibration—each noise—interfered with LIGO's ability to detect gravity waves.

Certainly the LIGO team could account for noise, damp it out, calibrate it out of relevance. But that only worked for noise they understood. Alex knew that Weiner was talking about a more se-

a single pulse; it went on for hour
the same frequency, 46.53 Hz, rul
out both supernova events and bin
neutron star coalescence. Nor did it
main steady. The effect fluctuated lik
noise source, which ruled against
possibility of a pulsar generating a gr
ty wave train as it rotated 46.53 tir
per second. Hanford's twin detecto
Louisiana saw nothing, and neither
TAMA in Japan. Their once-promis
signal was merely—noise.

When it vanished, the team at LI
prepared to chalk it up to some sh
lived seismic disturbance—until
noise came back the next day, and
next, and almost every day for t
straight weeks. No one could find
cause.

Slowly Alex dismounted and pul
off his helmet. Wheeling his b
around, he saw Weiner standing bef
LIGO's front entrance, ramrod-straig
arms crossed. The massive bunker t
shielded the southwest beam tu
stretched off to the left; the bunker
the northwest arm was hidden beh
the main building.

As Alex joined Weiner he imagir
the vibrations caused by his own ste
by the tires of his bike rolling along
pavement. He supposed this was h
the Grinch felt, with all the Wh
down in Whoville throwing a nev
ending party at his expense. "Scr
this," Alex told Weiner. "I say we p
process it out of the signal and w
on it off-line."

Weiner shook his head, wispy g

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detector. When noise appeared the PEM was supposed to help pin down the cause. But the PEM wasn't quite completed, and LIGO was effectively the most sensitive vibration detector in the world.

"It proves we still don't know what the hell is going on," Weiner rasped. "So on Monday we start going over every inch of this place."

Alex sighed. "So what do you want me to do about it tonight?"

"I want you and Randy to rebuild the final amplifier."

Four hours of busy work on his perfectly functional laser. "Patrick, we've already done that twice in the last—"

"Goddammit," thundered Weiner. "Don't give me that! I am trying to commission this observatory and I am getting very tired—" He broke off and dug a thumb into the bridge of his nose. "Randy's in the control room," he muttered, and then stepped inside.

Alex took a deep breath. They'd all been under pressure to find the noise source, and Weiner, as director of the observatory, had borne the brunt of it. Still, he'd never shouted before. Alex followed Weiner and tried not to think about what would happen if the noise went on for another week.

In the control room Alex found most of the crew seated around various monitors. Weiner was absent, presumably in his office. Alex slung his bike saddlebag onto a desk, turned to his fellow Caltech alum, Randy, and raised a questioning eyebrow.

"All at once," said Randy. "Just like last time. And the PEM says all quiet."

Goddamned noise.

"I've started a pool," Randy continued. Randy was the optics tech, while Alex's specialty was lasers. They were a de facto team, and Alex had come to appreciate Randy's determinedly cheerful outlook. "Todd picked early warning for Mount Rainier."

"That would make Todd happy." Todd, their vacuum tech, hated Seattle.

"Sonia thinks Hanford is burying waste illegally, but she's a conspiracy nut. Me, I think it's a bug in our post-processing code."

Alex grunted. How ironic if the noise was a phantom introduced by the very software designed to remove it.

"Five bucks. You in?"

"Yeah, I'm in."

"What should I put you down for? No one's taken quantum-foam fluctuations."

Alex paused, then smiled. "Whos."

"Whats?"

"No, Whos. Put me down for Whos down in Whoville."

Randy barked out a laugh. "I like that. 'All the noise, noise, noise, noise.' Well, Mr. Grinch, you're not the only one stuck here on a Friday night."

A muffled burring interrupted Randy's complaint. Alex dived for his saddlebag and pulled out his cell phone.

"Hot date?"

"I wish," muttered Alex, as he flipped it open.

"Well, don't take too long, lover boy. We've got work to do."

Alex waved Randy off. "Chow here."

"Alex, it's me, Steve." Steve Welch, Alex's old roommate at Caltech and now a physicist at PNNL, the Pacific Northwest National Laboratory, located a few miles away on the eastern edge of Hanford. "I need a favor, buddy."

"I thought it was your turn to bail *me* out of something."

"Hah. Bobbie and I have tickets for a concert at the Gorge tomorrow night, but I can't make it." The Gorge was a natural amphitheater that had been turned into a concert venue overlooking the Columbia River about sixty miles northwest of Richland. Locals hated it, but it had gorgeous views of the river and drew some big names. "There's some kind of Chinese fire drill going on at 200 East," Steve continued. "I'll be stuck here at work."

Alex gazed heavenward but let the phrase pass. "What's going on? The waste tanks all breach at once?"

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Silence, and for a moment Alex thought he'd lost the signal. For a moment after that he thought he was right, and millions of gallons of radioactive waste were seeping toward the Columbia River. Then Steve chuckled. "If I told you, I'd have to kill you."

"So you want me to take Bobbie to the Gorge for you."

Steve cleared his throat. "No, Bobbie doesn't want to go without me. We're—um—giving the other ticket to Bobbie's sister, Rebecca."

"Ah, the infamous Rebecca." Alex stopped, brow furrowed. "Is this a date?"

"Hell, no. We just think it's a damn shame two of our favorite people haven't met each other yet. She's a really fun gal, Alex. I think you'll like her."

It *was* a date. "I don't know. We're having some trouble here, too—"

An alarm went off, filling the control room with its shrill squeal. Not again. No wonder Weiner was so tense.

"What the hell is that?"

"We're having trouble with our smoke alarms." Alex had to shout to make himself heard. "They're not pulling enough current, and the amp circuits we rigged up keep failing." Around him, catcalls and curses competed with the piercing drone. Alex looked around at the sterile room and his too-familiar coworkers and came to a decision.

"Okay, I'll go. I'll call Bobbie and set it up." Alex tossed the phone aside and picked up a multimeter. Even a blind date with his best friend's sister-in-law had to be better than this.

Rebecca Tyler felt as though she were drowning in digits as she double-checked the report of fiscal-year expenditures on her screen. She stared at the number of cases of masking tape the 200 Area operators had used to tape their whites together—it kept the radioactive dust out—until the number began to take on a cosmological significance. It certainly seemed more significant than her endless updating of the Hanford Nuclear Reservation's official website, a mismatched, impenetrable hodge-podge of feel-good press releases and dry engineer-speak.

She closed her eyes and dug her thumbs into her temples, no longer able to deny the truth. She'd quit a challenging job in Silicon Valley, cashed out on her condo, and moved back to small-town Washington to escape the rat race and be closer to family. She'd landed the job at Hanford, the original plutonium factory—and to Rebecca one of the most morbidly fascinating places on Earth. Now, after just six months, she was bored stiff. Had she liked being a rat?

Rebecca shook herself, saved the spreadsheet, and called up her to-do list. There had to be *something* interesting left on it. Resignation warred with frustration as she scanned the list. A proposal for ventilation system upgrades, the latest press release on the vitrification plant, last week's Liquid Observation Well readings, this week's LOW readings. . . .

That was odd. She'd received the radiation readings for the nuclear waste tanks in the 200 West Area, but the 200 East numbers were late. Carl Werther, the operator in charge of compiling the LOW readings for all the tank farms in 200 East, usually got the numbers to her by noon each Friday. Rebecca grabbed the phone. It was past quitting time, but if Carl was still working on the numbers he might be there.

"Carl Werther."

He was. Rebecca automatically adopted the flirtatious manner that had charmed information from overworked programmers for a decade.

"Carl, it's Rebecca. Sorry to pester you, but you haven't sent the 200 East readings yet."

Silence. It stretched on, for three—four—five beats.

Unnerved, Rebecca cleared her throat. "Carl? Are you there? Is this a bad

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time?"

"No. Yes." A sigh, so deep and heartfelt she could almost feel warm breath on her ear. "We're having trouble with our dry well van." Rebecca recalled that the tank farm operators used vans to ferry gamma ray detectors from tank to tank.

The phone rang—a call on the other line. She raised her voice over the bell. "200 West is done with theirs. Can't you just use their van?"

"Hey, sounds like you got another call. I'd better let you go."

"Wait a minute, Carl, I'll take a message—"

Click.

Rebecca stared at the phone for another two rings, then jabbed at the other line. "Tyler here," she snapped.

"Hell-ooo," said a high, thin voice. Her niece Stacia, who could hold a conversation and hold a phone, but hadn't quite put the two together.

"Stacia, did you call me?" The wonders of speed dial.

"Nuh-uh. Mommy did. But the s'getti's boiling over so she said I could talk to you 'til she gets back."

Rebecca sighed. "Tell your mommy she picks great times to call."

"Okay. Are you bringing Ellery over tonight?"

Ellery was Rebecca's five-month-old basset pup. "Maybe tomorrow, honey. Is Mommy coming yet?"

"I'll ask her." A loud thunk as Stacia dropped the phone, followed by the diminuendo of her voice as she scurried away, calling for her mother. A moment later Bobbie spoke, sounding breathless.

"Sorry, Becky." Bobbie insisted on calling her Becky, a name Rebecca had shed during college. "I hate dealing with tomato sauce when it's all caked on the stove."

"No worries, Bob." Bobbie also hated to be called Bob. "But I can't make dinner, so—"

"That's not why I called. How would you like to see a concert at the Gorge tomorrow?"

"What's the catch?"

"There's no catch." Bobbie almost sounded affronted. "There's something going on at 200 East and Steve's been called out."

Rebecca straightened. 200 East again. "Something's going on? Did he say what?"

"He can't talk about it." That one sentence held a wealth of misgiving. Operations at Hanford had become much more open since its heyday as a producer of weapons-grade plutonium, but on occasion Steve still had to keep secrets from his wife. "We don't want the tickets to go to waste, so we thought of you."

"Girls' night out?"

"Uh, no." Bobbie coughed. *Here it comes. . . .* "We thought we'd give the other ticket to Alex Chow—you know, that friend of Steve's we're always telling you about—"

"You're setting me up on a *date?*"

"Becky, he's a doll. He just has a hard time meeting people. And so do you." Bobbie's voice turned wheedling. "He grew up in Oakland. You two can reminisce about the Bay Area."

Rebecca bit her lip.

"We'll puppy-sit for you." An exasperated sigh. "Becky, we love you, but a four-year-old niece does not a social life make." As if on cue, Stacia squealed in the background.

"All right, already."

"You'll do it?"

"I said I would. Now let me get back to work before I change my mind."

"Becky, it's six-thirty on a Friday. Go home to your dog."

Rebecca hung up and stared at the phone. She'd left the Bay Area to be closer to family, and now she had a job she didn't like in a town that no longer felt like home with a sister who was setting her up on blind dates. How much worse could things get?

* * *

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State Highway 240 cut through Hanford on the way to the Gorge, and Alex alternated views of sagebrush whizzing past the Jeep at eighty miles an hour with stolen glances at the driver—the infamous Rebecca Tyler. She seemed trapped in her own thoughts, which probably revolved around how much she regretted agreeing to this date.

Rebecca was pretty, of course; she was Bobbie's identical twin. But Alex would never mistake them for each other. Where Bobbie's honey-brown hair was short and practical, Rebecca's fell down her back in a long cascade. Where Bobbie was comfortably round, Rebecca was thin—almost too thin, and drawn. Where Bobbie was cheerfully casual, Rebecca was intense and a bit forbidding.

God, just get me through the day unscathed.

"You know," he said, desperately searching for a topic of conversation, "I've been working at Hanford for over a year now and I still haven't seen much of it."

"It's mostly desert. There's not much to—" Rebecca glanced toward him, then did a classic double-take. "What the hell?" She pulled off the highway with a twitch of the wheel and Alex grabbed the strap above the door as the car skidded to a stop in the gravel along the shoulder. They sat in silence for a moment before Rebecca turned to him with a dazzling smile. "Here's your chance," she said. "That's 200 West. You want to take a look?"

Alex blinked at her, then shrugged dumbly.

"There's a pair of binoculars in the glove compartment." Rebecca had already opened her door and hopped out. Hot desert air blasted through the air conditioning. He shook his head, retrieved the binoculars, and followed.

They leaned against the side of the car and Rebecca brushed wind-blown wisps of hair from her face as she resolutely turned Alex toward a group of buildings that were little more than white smudges on the horizon. Even when viewed through the binoculars they differed only in numbers of smokestacks. "Are those the tank farms?"

"No. That one's the Plutonium Finishing Plant. It's got the tightest security on site—there's still plutonium stored there. You knew that Hanford supplied the plutonium for the Nagasaki bomb, right? Fat Man. Or was it Little Boy? I can never remember."

"Fat Man."

"That other one is T-Plant. Or maybe U-Plant. And somewhere over there is a dried-out settling pond that's the world's only plutonium strip mine. The tank farms are all underground. More surface area to leak from, I guess."

Alex raised his eyebrows wordlessly and Rebecca grinned for the first time, instantly transforming from a forbidding beauty to the pretty girl next door. "Sorry. Working at Hanford nurtures a twisted sense of humor." She slipped off her sunglasses, shocking Alex anew with the ice blue of her eyes. "Hand 'em over," she said.

Alex passed her the binoculars, but instead of studying the buildings Rebecca trained them on empty desert to the north. Not quite empty, Alex saw—six small white dots were spread out on the horizon. Was this why she had pulled over? "Are those people?" he asked hesitantly.

The crunch of gravel interrupted them as a Hanford security van pulled up behind Rebecca's car. A big, red-faced man wearing jungle fatigues climbed out and sauntered over, his expression as blank as his mirrorshades. "Is there a problem here?"

"No," Rebecca shot at him. "At least there shouldn't be, since this is a public highway."

Alex sucked in his breath and imagined what he would tell Steve. *Fun gal. Oh, your sister-in-law is a fun gal.* The guard pulled out a notepad and methodically copied down her license plate

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number.

"Army?" whispered Alex.

"Private security. They think it's cool to wear camo."

The guard eyed the binoculars dangling from their strap around Rebecca's neck. "Ma'am, I'm going to have to ask you to get back in your car and get back on the road."

Rebecca snorted. "This is ridiculous. I work for the Office of River Protection and I'm just showing my friend some sights. Look, here's my badge—" and she fumbled with the catch of the purse hanging at her side.

"Keep your hands where I can see them," snapped the guard. Rebecca froze, eyes wide. The guard made a show of unsnapping his holster and Alex resisted the urge to close his eyes. "I'll tell you just once more. Get back in your car and get back on the road."

Rebecca slowly lowered her hands and studied the guard, lips thinned to a tight line. "I do not appreciate being treated like a criminal."

"Ma'am, you'll see exactly how I treat criminals if you don't get back in your car."

Alex took her arm. "Rebecca, let's go."

She jerked away. "At least get desert camo. You look like an idiot." The guard reddened. Rebecca spun on her heel and marched to the driver's side, while Alex slid into the passenger seat and sank down as far as he could. Rebecca threw the car into gear and stomped on the gas, but as Alex watched, her glowering look faded, to be replaced by a faint smile.

"Curiouser and curiouser," she finally said.

As the lights came up on the opening act Rebecca realized to her surprise that she was enjoying herself, and not because of the entertainment—a wild-haired Celtic songstress backed by three unearthly sopranos dressed like trees. It must be everything else: the lovely view of the river below; the evening breeze, bearing the scents of warm grass and cows; the ever-growing quilt of stars, slowly spreading over them from the darkening east.

And Alex. He touched her arm and pointed to the horizon. Out past the stage a brilliant point of light danced above the quicksilver ribbon of the river. "Oh," she breathed. "Venus."

When Bobbie had first introduced them Rebecca had had her doubts—Alex was taller and better-looking than expected, with thick black hair and a lean build, but he'd had trouble meeting her eyes and his smile was strained and shy. The encounter with the guard broke the ice. They spent the rest of the drive engaged in a good-humored debate about the Bay Area—Vietnamese food versus Thai, Kepler's versus Cody's, Giants versus A's—and Rebecca's misgivings faded.

"So. . . ." Alex hesitated, and Rebecca glanced over a bit dreamily, still entranced by the Evening Star. "Can you tell me what you were really looking at with those binoculars?"

She straightened in her seat as the romance of the moment evaporated and tried to shrug off her disappointment. Alex *was* a scientist. Not so surprising that to him Venus was just a planet. "Six Hanford workers with radiation detectors out in the middle of nowhere."

"That's unusual?"

She nodded. "I update the survey schedule, and there was nothing on for today."

Instead of shrugging it off as she half-expected, Alex raised one eyebrow, suddenly looking very elegant. "Ah. A mystery."

"Exactly. And one I might have solved if not for that damned guard." She raised a fist. "If he wanted criminal activity, I should have decked him."

"Well, I'm glad the date didn't end there." As the words hung in the air Alex reddened and looked away. Rebecca decided perhaps the scientist wasn't

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immune to Venus after all. "So . . . mysteries," blurted Alex. "We've got plenty of them at LIGO. You should come work with us."

Rebecca took pity on him. "What kind of mysteries?"

"Big ones. We're looking for a missing piece of the Universe, the Einstein prediction that no one has actually seen. Gravitons. Gravity waves, they're usually called."

"Oh." A mystery of a different sort, but, Rebecca had to admit, still a mystery. "Didn't Newton settle that a few hundred years ago?"

"Not gravity, gravity *waves*. Ripples in space-time." Rebecca raised an eyebrow. "Let's see. The Earth orbits the Sun because of gravity, right? So what if the Sun suddenly disappeared?"

"Um, the Earth would go flying off into space?"

"Yup—but not for eight minutes." Alex grinned at her puzzled look. "It makes sense. Honest. Information can't travel faster than the speed of light, and light takes about eight minutes to get from the Sun to us."

"Where do gravity waves come in?"

"That's what would carry the information. A huge gravity wave, launched out from the Sun at the speed of light."

"I'll take your word for it, but I hope you're not planning that particular experiment."

Alex shifted towards her in his seat and his voice gained strength. "No, we're hoping to see more distant events. Gravity waves are generated by accelerating mass—like two black holes spiraling in and colliding, or a black hole sucking up a neutron star." Rebecca watched his fists twirl about each other, then come together, knuckle to knuckle, as he made a slurping noise. She chuckled, and Alex blushed and dropped his hands back in his lap. "To tell you the truth, I don't know much about that stuff. I'm a laser guy."

"Why lasers?"

"That's how we look for the gravitons. I've been helping install a new laser—much more powerful than the last one. Plus we doubled the arm length, put in sapphire mirrors, better shielding, better noise damping—" he faltered. "Though I wish the Whos would leave us alone."

"What does Roger Daltrey have to do with it?"

Alex grinned. "Wrong Whos. These Whos are noisy little— Uh, let's start at the beginning. Do you know how interferometers work?"

"I don't know what 'interferometer' *means*."

Alex froze in his seat, then turned to the stage. "I'm sorry," he said. "I'm boring you."

Rebecca felt a sudden pang at how shy he was. "No. No, you most definitely are not boring me. But you *will* make me mad if you don't explain."

Alex took a deep breath. His gaze made it as far as her left ear. "Well, that's where my laser comes in." He held out both hands, palms up. "Give me your hands."

Startled, Rebecca blinked.

"I'm not going to bite." Rebecca slowly placed her hands in his. He aligned them, heel to heel, a right angle between palms. "This is LIGO. Your hands are four-kilometer-long vacuum tubes, with sapphire mirrors at your fingertips. Say there's a laser here." He indicated a point between her wrists. "It enters the tubes here—" the junction of the palms "—gets split, and two beams travel the length of the tubes, hit the mirrors, and bounce back." He drew his fingers lightly along her hands out to her fingertips, then back. She shivered and hoped he didn't notice.

"We set it up so the returning beams cancel each other out. That means we don't get any light on our detector. But if there's a gravity wave that comes in, space itself starts oscillating. It's best if the wave comes in vertically—" he raised his palm and brought it down onto her hands "—so the lengths of the

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two arms oscillate with respect to each other." He tugged on the tips of her fingers, first one hand and then the other. "And when the laser paths change, they no longer cancel each other out, and then the detector lights up."

Two yuppies in fleece and Birkenstocks brushed past them carrying plastic cups of white wine and Rebecca pulled her hands back. The lights dimmed. "I guess we'll have to continue this conversation later," she whispered. Alex smiled.

Suddenly she heard hushed voices and a stifled cry. She glanced at Alex, who was staring down at the concourse, his nose wrinkling. "Do you smell that?" he asked.

"Smell what?" Even as she spoke, Rebecca caught the acrid scent of smoke.

"Fire!" Someone below them sprang to his feet, pointing at the plastic mesh fencing that enclosed the seating. Others near him took up the cry, and Rebecca felt the crowd rumble and stir. The smell of smoke grew heavier. She realized she was gripping Alex's hand.

"Don't worry," he said. "We're outside. We're not going to die of smoke inhalation."

Then he winced. The yuppies in Birkenstocks were stepping on his feet as they pushed past in the other direction. They'd forgotten their wine.

The lights came up as the public address system gave a crackle of static. *"There is no cause for alarm. Please proceed in an orderly manner toward the nearest exit. There is no—"*

Something blunt and heavy slammed into Rebecca's shoulder. She cried out. A balding man in hiking boots had climbed over the seat next to her and into the aisle, then swung a woman down after him. "Watch it," Alex snarled. He stood, pulling Rebecca with him, and wrapped his arms around her. The couple hurried off without another look.

Around them, the shouts grew louder as a steady stream of people fought their way to the concourse. A hellish red glow blazed beyond the fence, and she could see the silhouettes of amphitheater personnel aiming tiny fire extinguishers at it. Sparks snapped into the darkening air. The grass! They were in an outdoor venue, and the nearest fire station was in George, fifteen miles away. *"There is no cause for alarm—"*

Rebecca and Alex fought to keep their feet as they were pushed and shoved and cursed. The closest exit lay near the blaze, and Rebecca watched as the mob thinned and bunched, split apart and rejoined, trying to decide whether to hurry past the flames or choose another route. All the while Alex held her tight and protected her from the buffeting.

The mass of people flooding around them thinned. "C'mon," Alex said, pulling her after him, deeper into the seats, away from the fire. He timed their progress so they remained at the back of the last wave flowing toward the exits on the far side of the amphitheater.

Rebecca heard screams and looked behind. The fire had spread, and the people still trying to escape from that exit had turned back. "They'll head this way."

Alex looked back and nodded. "We're all right. Almost there—" He pulled her up next to him, wrapped an arm around her, and shoved his way into the bottleneck at the tiny upper exit.

The crowd grabbed them, squeezed them together, pulled them apart. Rebecca felt Alex's arm slide away. She lunged after him. "Alex," she cried. And then they were through.

They fought their way out of the main stream of people and stopped, gasping for breath. Around her Rebecca could hear sobs and swearing, and the first far-off wail of a siren. Her shoulder throbbed. She let Alex pull her close, but she could feel him staring over her shoulder.

"Why didn't the alarms go off?" he said.

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* * *

When Alex arrived at Steve and Bobbie's for dinner he felt absurdly grateful for the fuss Bobbie made over him even as he fended off her questions, accepted a beer, and let her herd him toward the couch. She deposited a second bottle on the coffee table in front of Steve and turned to Alex. "Don't tell the whole story yet. I have to fluff the rice."

Steve stared at the bottle as his wife vanished in the kitchen. "I shouldn't," he said. "I'm going back to Hanford after dinner."

Alex gaped at Steve, who looked worse than he ever had during finals at Caltech. His dark curly hair was still damp, as though he'd just taken a shower. Alex hoped he'd gotten some sleep with that. "You look like crap."

Steve's mouth twisted in a wry grin. "In that case. . . ." He twisted off the cap and toasted Alex before taking a long draught. Stacia scrambled onto Alex's lap, preventing him from pressing the issue. Instead, Steve got in the next question. "So, what do you think of Rebecca?"

"Before or after we nearly got trampled?" Steve rolled his eyes and Alex stalled for time by teasing Stacia with the cold bottle—she giggled and squirmed as he laid it against her bare calf. What did he think? For a moment all he could remember was how Rebecca had felt in his arms. "A little high-strung, but I like her," he finally said. "I'd hate to be on her bad side, though."

"Why? What happened?"

As Alex described the encounter with the guard, Steve's smile faded. "That's Rebecca," he said quietly, shaking his head.

Just then the front door burst open and Rebecca herself swept in, a squirming basset puppy in her arms. "Hey, everybody," she called. The puppy barked. Stacia leapt off Alex's lap and dashed toward her aunt.

Alex almost spilled his beer. "Steve, you didn't."

"Bobbie's the mastermind." But Steve was grinning.

Rebecca handed the puppy to Stacia, who giggled as he snuffled and licked at her face, his big ears flapping. Rebecca looked up. "Oh, Steve, you're home—" She broke off, and Alex saw confusion, then recognition, and then a brilliant smile. He rose, conscious of his foolish grin, feeling like his heart had just restarted.

"Dinner's about ready," Bobbie called from the kitchen. "Steve, I could use a hand with the table. Stacia, put Ellery in the back yard. You can play with him after dinner." Alex endured his own face-licking as Stacia gravely introduced him to the puppy, then Steve hustled his daughter out of the room. Leaving Rebecca alone with Alex.

"How . . . how are you?"

"Fine," she said, too quickly. Then she shook her head. "Actually I've got quite a few bruises. That jerk in the hiking boots really nailed my shoulder."

"You should have decked him."

She came closer, peering at him as she sank into Steve's vacated chair. "You're making fun of me, aren't you?"

"Oh, no. If I wanted to do that, I'd call you Becky."

"Once," said Rebecca grimly. "You would call me Becky once."

"Come and get it," called Steve. "And bring my beer."

Somehow Alex ended up next to Rebecca. "Did you find out what happened last night, Becky?" asked her sister as she served the potstickers and cashew chicken.

"Mommy, why do you call Aunt Rebecca that? She hates it."

Steve snorted in mid-chew while Rebecca leaned back and crossed her arms. "Yes, Bobbie, why *do* you call me Becky when I hate it?"

Bobbie simply smiled. "I'm her sister, honey. Sisters are allowed."

"Will you and Daddy make me a sister?"

Bobbie turned a delicate shade of

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pink while Steve hushed his daughter.

Rebecca exchanged an amused look with Alex. "Some idiot cook thought he put out a burning hamburger and tossed it in the trash. But, as Alex noticed, none of the smoke alarms went off. When he finally realized the whole trash can had gone up he panicked and kicked it outside onto the grass." She neatly plucked a cashew from her plate and popped it in her mouth. Stacia, who had insisted on her own pair of chopsticks, watched intently. Alex tapped her on the arm, pointed at Rebecca and held a finger to his lips. Stacia nodded, her eyes growing huge.

"None of the smoke alarms?"

"Not a one. I called Jan—you know, the editor at the paper where I send all the press releases—and she said someone removed all the batteries." Rebecca plucked up another cashew.

"For heaven's sake, why?"

"One of the janitors says the alarms went off and wouldn't stop." As she raised her chopsticks Alex reached out and neatly pinched the back ends together. Rebecca's cashew dropped onto her plate. Stacia squealed with laughter.

"Do I have to put you both at the kid's table?" asked Bobbie.

Rebecca glared at him, but the corners of her mouth were twitching. "Perhaps Mr. Mature could prove he's an adult by contributing to the conversation."

"I've been dealing with enough smoke-alarm problems, thank you very much. Though if they got theirs from the same place we got ours, someone has some serious 'splaining to do."

"You're having trouble with your alarms?"

"Yeah, but we don't disable them."

"That's weird." Rebecca toyed with her food. "What could be going wrong?"

Alex shrugged. "They should be fairly foolproof. You have a little radioactive source that ionizes some air and completes an electrical circuit. Smoke gets inside and stops the current, which sets off the alarm."

"But they were going off without any smoke," said Rebecca thoughtfully. She looked at Alex. "So what's turning off the radioactivity?"

He blinked at her. *Oh, God, keep a straight face or you'll never see her again.* He looked to Steve for help, and his friend chose that moment to launch into a coughing fit. Bobbie pounded him on the back until he waved her off, napkin to his streaming eyes.

"Sorry," Steve gasped, reaching for his beer. "I bit into a pepper."

"Well?" asked Rebecca.

Alex took a deep breath. "You don't 'turn off' a radioactive source."

"But I thought you said—then what's causing the problems with the smoke alarms?"

"We don't know yet. But we *do* know the laws of physics."

Rebecca straightened and eyed him coolly. "How nice for you."

"Not that it's not a good question," said Alex quickly. "It's just best to start with simpler assumptions. Like bad wiring or something. Occam's Razor, you know. Uh, have you heard of Occam's Razor?" Steve kicked him.

"I am familiar with Occam's Razor."

"Occam, schmoccam," said Bobbie. She poured Stacia another glass of milk. "How long have your smoke detectors been acting up?"

Alex felt like he was, indeed, at the kids' table. "About two weeks."

"So much for your razor. *I* think Becky asked a perfectly reasonable question."

"I'm not saying it wasn't—"

"Jesus. Look at the time," said Steve. "I'm sorry, honey, but I have to get back to work."

"Right now? You've barely touched your dinner."

Steve stood. "Conference," he said, and Bobbie followed him into the hallway.

Rebecca stabbed at chunks of chicken with her chopsticks as though she were squishing ants on her kitchen counter.

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Or condescending physicists. Did she consider the two equivalent?

Stacia swiped a forearm across her milk mustache. "Occam schmoccam," she said, with obvious relish. "Occam schmoccam."

Rebecca tapped her finger against the steering wheel as she waited in line at the Wye Barricade, one of the security checkpoints for employees entering Hanford. The longer she sat, the more she thought about the men's reaction to her question the night before, and the madder she got. Maybe they thought her ignorant, but something strange was happening; if they were too blind to connect the dots, she'd do it on her own.

As she drew closer to the checkpoint she saw the reason for the delay. Instead of following their usual practice of glancing at proffered badges and waving the cars through, the guards were stopping each car and closely examining each badge. Many cars were turning back.

The last car ahead of her sped away from the checkpoint. Rebecca rolled down her window and plastered on her best smile, praying the guard wasn't the one she'd insulted Saturday. Her prayer was answered, but the guard looked tired and Rebecca realized she probably had some fast talking ahead.

"Badge?" She handed it to him. He studied it and frowned. "Ma'am, we're locked down pretty tight right now. Only personnel actually assigned to these areas can enter."

"You weren't informed?" Rebecca frowned. "Dr. Welch—Steve Welch—requested that I come out." She leaned out the window and spoke in a low, conspiratorial voice. "Sooner or later, we're going to have to make the situation public, and we're going to have to be very careful with the announcement. We don't want a panic."

The guard flipped through several papers on a clipboard—probably searching for Steve's name—and then studied her. Rebecca tried to look earnest and concerned. "What's in the container, ma'am?" He pointed to the Tupperware bowl on the passenger seat.

"Brownies." She pulled it onto her lap and lifted the top. "Baked them myself. Would you like one?" The guard hesitated. His hand snaked into the bowl and emerged with a brownie. He stepped back and waved her on. Rebecca sped off before he could change his mind. Men were so predictable.

She pulled up in the parking lot of the office complex known as the Smurf building—Westinghouse had painted it their signature blue just before losing their contract—and hurried inside before anyone else could challenge her, bowl clasped to her chest.

Carl Werther's cube was on the second floor, and as Rebecca wound her way through the rabbits warren of corridors she tried to match the purposeful strides of the few people who passed her, their faces exhausted but intent, most of them with cell phones plastered to their ears.

The second floor was quieter, desk after desk deserted, but Carl was in and not happy about it. He stood at his window, gazing forlornly out over 200 East. A big teddy bear of a man, Carl reminded Rebecca of a toy whose owner had run off to play without him. She knocked on the wall of his cube.

"Jesus. How'd you get in here?"

"Good to see you, too, Carl."

"You shouldn't be here, Rebecca. And what's that?" He pointed at the bowl.

"A bribe."

He groaned. "Your brownies? That's downright cruel. I can't talk to you."

She set the bowl on his desk, peeled off the lid, and took a seat. "Where are the LOW numbers for last week, Carl?"

"I can't talk to you."

"Cream cheese swirl, with chocolate-cream cheese frosting."

He dropped into his desk chair and buried his face in his hands.

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"If you can't talk to me, then listen." She had to be right. She *had* to be. She'd lain awake last night, thinking this through over and over again. "Something's going on here. Something to do with the radioactivity in the tanks, or I'd have gotten the readings from you. I did get the readings from West, so the tanks in East and West must not match."

Carl lifted his head and stared at her.

"The numbers from West looked normal. I'm betting your numbers are low."

Carl blinked at her. "It's not a spill," he rasped, and cleared his throat. "We've looked at in-tank video for every damned tank and the waste levels all look normal."

"But the radiation levels are low." Carl's wince confirmed her statement. "What about the dry wells? What about the water? What about waste dumps? What about the background?"

Carl hunched his shoulders. He stared at his clasped hands in silence.

"They're *all* low?"

Carl reached for a brownie.

"Jesus," Rebecca breathed. "I hadn't expected that. Where is everyone?"

"Out surveying, seeing what sites are affected while it's still happening," he said around a mouthful of brownie. "Last night they widened the search area."

Steve, and his sudden exit from dinner. She *had* asked the right question, and the jerk had left her hanging. "What do you mean, while it's still happening?" Carl looked at her. "C'mon, Carl. You already got a brownie."

He sighed. "The effect isn't constant. Sometimes the radioactivity is really low, and sometimes it's not." He offered Rebecca the bowl.

"The natural background, too? That's weird, Carl."

"Tell me about it." They munched in companionable silence.

"So what are you doing here?"

"I'm burned out, remember?" Carl had hit his maximum yearly exposure when his respirator hose popped loose at the wrong time and place. That meant a desk job for the next six months. "I think they just needed a body to stay behind and plot their findings."

"Plot? You've got a map? Show me."

Carl shrugged. "I didn't want to work here, anyway." He motioned her around the desk and pointed at his monitor. Colored dots spattered a detail map of the entire Hanford site, most dots in the 200 East and 200 West tank farms, but not all. Rebecca suddenly knew what those surveyors had been doing in 400 West on Saturday. "Red are normal, blue are cold," said Carl. "See the cluster of blue dots in 200 East? That's where we think the effect is localized."

Rebecca tilted her head at the screen, dissatisfied. True, red dots surrounded the blue cluster in all four cardinal directions. But she knew the effect was bigger than that. It had to extend southeast, down to LIGO, and northwest, sixty miles up to the Gorge.

"What if there's no center to the effect? What if it's a long thin stripe that cuts through Hanford?" She traced a northwest-southeast line on the screen. "See, no red dots along here."

Carl gave her a funny look. "Everyone's out checking the northwest area right now. But we know it doesn't go southeast very far. Everything looks normal around the FFTF." He pointed to a few red dots just southeast of LIGO.

"So it doesn't go much beyond LIGO. . . ." Rebecca trailed off, noticing on the map that LIGO's northwest arm pointed directly at the blue cluster in 200 East. "Or maybe it's coming *from* LIGO."

"What?"

Rebecca straightened. "Do you have a bigger map? One of south-central Washington?" As Carl fished around in a cabinet, Rebecca found a plastic protractor and measured the angle of the northwest LIGO arm on the monitor.

"Here," said Carl, handing her an old map. She spread it open, found the approximate LIGO location, and used the protractor to draw a line northwest. It

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didn't hit the Gorge exactly, but the two-mile deviation was well within her margin of error.

This cannot be a coincidence. She stared at the map, trying to ignore the chill that had taken hold of her stomach. What had Alex said on Saturday night? She closed her eyes and pictured his face, his voice, the feel of his hands as he shaped hers into a perfect little LIGO. What had he said?

Rebecca reached for a phone, but Carl dropped a big hand on it first. "Rebecca, this is serious stuff. There's crazy talk about secret weapons that neutralize A-bombs. And Kernighan's here from Grand Junction. I *will* lose my job, and probably worse, if this gets out."

"The Dragon Lady's not going to scorch your butt. I'm just calling my brother-in-law, Steve. He's with PNNL." She dug Steve's cell phone number from her purse, and Carl pulled his hand away.

Steve answered the call with gratifying speed. "Bobbie? I—"

"No, it's Rebecca. I need you to meet me at LIGO in a half an hour."

"I can't talk right now—".

"Then listen. The effect is coming from LIGO." She let him chew on that for a moment, and then said, "Bring a timeline of the dead periods. I need starting time and duration for everything you've tracked so far."

It took Steve a good five seconds to respond. "Well, if Stacia needs her daddy, I guess I'd better come home." The phone went dead, and Rebecca stared at it for a moment.

"You did say the Feds are already here?"

Carl nodded and pulled the whole bowl of brownies closer.

Rebecca sighed. "Could you hand me another one of those? I think I'm going to need it."

The daily visit from the Whos had come and gone, and with it most of the grad students. But that wasn't why Alex found it so damned hard to concentrate on the laser electronics. All he had to do was take five steps, check his email, and—

And Rebecca still wouldn't have written him back.

It had been foolish, he knew, to email her so soon, especially when she was probably still mad at him. What had he been thinking?

Okay—scratch that—he knew exactly what he had been thinking.

The phone rang, and Alex felt his heart leap as he realized it was the little-used second line, the number he had given Rebecca in his email. Clearing his throat, he picked up the receiver. "Chow here."

"Hi, Alex."

"I . . . I was hoping it might be you. What's up?"

"Remember that question I asked last night?"

Alex winced.

"Being right is the best revenge. Besides, Steve made suckers of us both. Listen to this."

Five minutes later Alex hung up the phone, shaking his head. Completely impossible. Wasn't it? He didn't know that much about nuclear physics, but Rebecca was already on her way over and he wanted to sound intelligent when she arrived.

He sat down at the computer and called up a scientific search engine while he phoned the control room. Randy answered.

"Hey, dude," said Alex. "Can you think of anything that would inhibit a decay process?"

A short pause. "Sure. Put an excited Rydberg atom in a conducting cavity—"

"No, not atomic decay. Nuclear decay."

"Jeez. Well, in principle you could do the same thing with a nucleus, but you'd need a *really* small cavity to inhibit a gamma ray."

"That's what I figured." Alex typed "slowed quantum decay" into the search

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field.

"What does this have to do with the noise?"

"What? Oh, nothing. Don't worry about it."

As Alex hung up, he noticed that the search engine had already come up with a dozen hits. He scanned through the titles, and noticed that two of the papers discussed an intriguing-sounding phenomenon called the Quantum Zeno Effect.

"Zeno?" he muttered. He clicked on the first article.

When Rebecca and a grim-faced Steve were ushered into the LIGO control room, she found Alex in heated discussion with two skinny guys. Off to one side, a white-bearded professor-type sat at a workstation and ignored the debate.

"But I thought the wave function doesn't really collapse," the taller guy was saying. "So how can—" He broke off after she entered, and in an instant all eyes were on her. Rebecca tried not to feel too self-conscious; this crowd probably didn't get out much.

"Hi, Alex," she said. "I brought Steve along. He's very . . . interested in all this."

Steve said nothing.

Alex looked from one to the other. "Rebecca, this is Randy Duncan, a friend of mine from Caltech. Steve, you remember Randy. That's Patrick Weiner, my boss. And this is Joe."

"No last name, just Joe," the shorter guy cracked.

Rebecca sat next to Alex but Steve didn't budge and she watched him, worried. She'd given him the impression she knew what was causing the lowered decay rates at Hanford, but all she really knew was that LIGO fit in—somewhere. Her job was usually to collect all the pieces and put them together, but this time she could only dump everything into one pile.

"We were just talking about this Quantum Zeno Paradox," Alex said. "It's the only thing I could find that might fit what you were talking about."

"Zeno *Effect*," corrected Randy.

"Right, right," Alex nodded. "It's *named* after Zeno's paradox."

Rebecca squinted. "The one where you could never actually get anywhere, because first you'd have to go halfway, and then half the rest of the way, and so on?"

"Wrong one, my dear." Weiner looked up from his workstation. "It's the instantaneous velocity paradox. Zeno claimed that an arrow could never move, because at every instant it's perfectly still, and a string of zeros still adds up to zero."

Rebecca tried to picture the instantaneous arrow. Steve, she saw with relief, was starting to thaw. "Quantum—" he ventured.

"Zeno Effect," finished Alex. "It's a way to slow down quantum decay rates."

Finally Rebecca made the connection. "Slowing decay rates? That's what I asked you last night." Both Alex and Steve had the grace to look shame-faced. "How does it work?"

"Observations," said Alex. "Do you know about quantum collapse?"

"Schrödinger's cat, right?"

"Sure. When the cat's in the box it's both alive and dead—that's called a superposition of states. When you open the box to observe the cat its wave function collapses into one state or the other. Same thing with radioactivity. You have a superposition of an undecayed nucleus and a decayed nucleus. Sometimes an observation collapses the system one way, sometimes the other. When it collapses into a decayed state, the nucleus decays, and that's radioactivity."

"So you can prevent decay by preventing observations?"

"Not preventing," said Randy. "Increasing. You have *so* many observations that the system is constantly col-

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lapsed."

"Wait. Wouldn't more observations just give the nucleus more chances to decay?"

"More chances to collapse," Alex agreed. "But it'll keep collapsing back into the *undecayed* state. If you want to get a decay you have to leave the system alone for a while and let it evolve into a superposition. If it starts off in a pure, undecayed state and you keep collapsing it back into that same state, it can never evolve much of a decay probability."

Rebecca groped for an analogy. "That sounds as crazy as Zeno's arrow," she said, with a glance at Weiner. "Sure, if an arrow froze every time you looked at it, constant observations *would* keep it from going anywhere. But looking at an arrow doesn't stop it in midflight."

"True," said Alex. "But in quantum mechanics, observations affect the system. The quantum Zeno effect is real. It's even been measured in the lab."

Rebecca shook her head. "Even so, what would cause it to happen here at Hanford?"

"Just a moment," said Weiner, swiveling away from his workstation. "You think this is actually *happening?*"

"Something's going on," Rebecca said, unfolding the map. "Take a look." They crowded around the blue and red dots as Steve explained about the radiation readings in 200 East.

"How can anything be affecting the waste tanks?" said Randy. "Aren't they pretty far below ground?"

"What about gravity waves?" asked Rebecca.

Weiner laughed. "We're not *making* gravity waves here, my dear."

"Patrick," Alex said sharply. "Rebecca understands what we do. Let her finish."

Rebecca glared at Weiner. Her stupid questions had been on the mark so far. She turned to Alex and took a deep breath. "You never did tell me about the Whos."

The men stared at her, wide-eyed.

"No," said Alex slowly. "I guess I didn't."

"Why don't you tell us now?" Steve asked in a dangerously quiet voice.

Alex blanched. "We're getting—uh—noise," he said. "That's not so surprising. We just haven't figured out where it's coming from. Yet."

Steve produced a printout of his own and slapped it down on Alex's desk. "Take a look at that," he said. "Tell me if it reminds you of anything."

Alex unfolded it and frowned, eyes scanning the page. Then he turned to his workstation, called up a spreadsheet, and scrolled through the lines. He rubbed his mouth with one hand. "The times match. When we get noise, you get low decay rates."

Rebecca smiled in triumph, but as she looked at the men around her she realized they didn't seem to share her relief. In fact, they looked more baffled than ever.

"Let's play 'what if'," said Joe. "What if a narrow beam of 46.5-Hertz gravitons was cutting through Hanford? That would explain why Louisiana can't see our noise. And the gravitons might be acting as a fast observer for the nuclear waste along their path, using the Zeno effect to freeze everything in an undecayed quantum state."

"A gravity-wave *beam?*" asked Randy. "Just a few miles across? Even if we could dream up some crazy mechanism, why would a gravity-wave beam just happen to be aimed right at us?"

"Because we're a gravity wave detector." Alex stared at his screen, a strange, pinched expression on his face. Then he opened another program, and began to type.

"Alex, what are you doing?" Rebecca asked.

"We're playing 'what if', right? So what if someone's sending us a message? The noise fluctuates. I never tried to look for big patterns, but—" His fingers sped over the keyboard. The others slowly gathered around him.

"This is ridiculous," said Weiner. "Of

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all the possible ways to communicate, gravitons have got to be the *least* efficient." He picked up the map and pointed to the red dots southeast of LIGO. "Besides, there's no effect down here, towards Richland. If it was a beam through LIGO you'd see the same thing on both sides."

Rebecca turned to look at Joe, and could almost see the processors whirring through his skull. "No, it doesn't make sense to communicate with gravity waves. Not from *this* Universe. But what if the ekpyrotic theorists are right?"

Randy squinted. "What does the Big Bang have to do with—"

"Think about it. Ekpyrotic theory gets rid of inflation by saying there's another 4-D universe, separated from ours by some fifth dimension. What if there are intelligent beings in that other universe? How would they communicate with us? Gravity waves. Gravity waves are the only way. Maybe the beam is entering our Universe right here at LIGO, heading northwest."

"Excuse me," Rebecca interrupted. "Other universes?" What the hell had happened to Occam's Razor?

"It's a recent spin on the Big Bang, from string theory," Joe explained. "You need to think of our 4-D Universe as the surface of a bigger, 5-D space. Then you have to imagine another, parallel surface—another 4-D universe. It's linked to a recent idea that gravity is so weak because it really lives in five large dimensions, and we only see the residuals. That's why gravity waves are the only thing that can go between universes."

Weiner shook his head. "But this beam is horizontal. If someone was trying to get us to see a signal, they'd send the gravity waves vertically. That's where LIGO is most sensitive."

"And why do we just see the effects in nuclear decay rates?" asked Steve. "You'd think the Zeno effect would apply to atomic states, too."

"Gravity couples to mass," said Joe. "Maybe electrons just aren't massive enough. I wouldn't have thought nuclei would be massive enough, either, but I guess it comes down to the unknown event that triggers a quantum collapse. Maybe this will finally tell us where the ultimate collapse really comes from."

Weiner scratched his beard. "An outside observer to collapse the wave function of our Universe. I wonder if stray gravitons could increase the proton lifetime? That would explain . . ."

Rebecca shook her head. How could they just drop the idea of other intelligent beings in order to talk physics? She tuned them out to watch Alex type. After another minute he hit a final key and slumped back in his chair. "It's running," Alex said. "Going through the largest string of noise data to see if it repeats anywhere."

"You never looked for that before?" Weiner asked.

"For short repeats, yeah," said Alex. "But I never imagined that it might be a long string. It was just noise—" A beep from the computer cut him off, and the program window output a few simple lines:

Repeat Length: 65536
Match Fraction: 0.999985
Sigma: 4.31

"Holy shit," muttered Steve. "Two to the sixteenth. That can't be a coincidence."

"Too bad it's not the product of two primes," Alex said. "Could have been a Sagan picture."

"Maybe it still is," said Randy. "Two fifty-six by two fifty-six. Plot it out."

The next step took nearly as long as the first, but this time Rebecca could appreciate the result. The screen filled with a large black-and-white image that didn't make much sense, but certainly wasn't random. The left half contained columns of strange characters while the right half looked like a series of pictures. And the largest picture looked familiar.

Rebecca pointed at the big L-shape.

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Her finger shook, and she couldn't make it stop. "That's LIGO," she whispered.

For a moment, no one spoke.

"Hey, Alex," said Randy. "You won the pool."

Alex peered through the cracked-open door at the mostly-empty LIGO visitors' area, scowling at the poor turnout. After three agonizing weeks the Feds had finally given in, permitting the most important press conference in history to go forward, and almost no one had shown up to hear the news.

"Five more minutes."

Alex jumped, then turned to see Randy grinning at him. "Jesus. Don't sneak up on me like that."

"Any cameras?" Randy asked.

"Just that one from Channel 6. Looks like about two dozen reporters, total."

"Rosenthal will be pleased." Randy turned to look at the nondescript man in the gray suit who was huddled in conversation with Kernighan, the Dragon Lady from DoE. Alex still didn't know which government agency Rosenthal represented, or even where he fit in the chain of command. "He probably didn't allow an early leak," Randy continued. "That's why no one's here."

Alex shook his head. "Rebecca emailed me a copy of the release an hour ago. It actually used the phrase 'major announcement of the utmost scientific importance.'"

"Did it say DoE?"

"No. LIGO. Why?"

Randy snorted. "Rosenthal probably saw to that. A 'major announcement' from LIGO. Who do you *think* is going to show up?"

Light dawned. These were *science* journalists, waiting to hear about the first detection of gravity waves. Alex almost laughed, thinking about how much more was in store for them.

"What's so funny?" Alex turned to see Weiner approaching, followed closely by Balusu, the SETI guy from Berkeley.

"Just. . . . Nothing."

"Who is in the room?" Balusu asked. He ducked behind Alex and peered through the door. "Ah, good. *The New York Times* and *WiredNews*, both. Very good."

"The room's nearly empty, Dr. Balusu," Randy said.

"Less chaos. Better questions."

"Gentlemen." Rosenthal strode toward them, one hand raised. Kernighan followed with an ill-concealed look of distaste. "Remember your briefing. Please keep to your prepared statements." Alex caught Rosenthal's eye, but the man's gaze emitted less information than a black hole. "If you receive a question even the slightest bit outside the prescribed limits, what do you say?"

"No comment," Weiner spat.

Rosenthal eyed him. "Very good." He paused. "I understand this is a momentous event, gentlemen. I sympathize with your eagerness to inform the public. But unless we're very careful, the public may not react in quite the manner you expect."

"They're from another universe, for Christ's sake," Randy muttered. "They're not a threat."

"We don't know what they are, Dr. Duncan." Randy said nothing. If Rosenthal didn't want to alarm the public, thought Alex, he shouldn't have turned LIGO and sixteen square kilometers of desert into a high-security exclusion zone. But, like Randy, he kept quiet.

Rosenthal pushed open the door to the visitor's center. "It's time." Kernighan sailed through first, followed by Balusu, Weiner, and Randy.

"Alex, wait!" Rebecca hurried toward him down the corridor. He caught his breath, then looked at Rosenthal, who raised one eyebrow but nodded and followed the others. She watched him go with an expression very like Kernighan's. "Is he still muzzling you?"

Alex felt a touch of foreboding. Rebecca had been haranguing everyone who came within earshot—including Rosenthal—about the need for full dis-

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closure. "Rebecca, let it go, please. We're all just following orders."

Rebecca looked away, her lower lip caught between her teeth. Then she turned to him with a brilliant smile that was like a shock to his heart. During the insanity of the past three weeks they'd spent barely fifteen minutes alone together, and he'd almost stopped thinking to himself, *when things calm down—*

—Maybe he shouldn't wait. Maybe he couldn't wait. He took her hand. "Meet me tonight in the LIGO control room?"

She nodded, her eyes shining. "Wouldn't miss it," she said. He was still trying to get the nerve to kiss her when she pushed him through the door.

The following ten minutes would remain a blur for the rest of Alex's life. His brain went on autopilot, somehow producing his lines without letting him stop to think about what he was saying. It wasn't until he sat back from his microphone, with Weiner leaning forward to drop the next bombshell, that he actually looked around the room.

Alex had played tour guide to high school science classes that boasted more bodies than this little group of reporters, but no bored student had ever shared the look on their faces. They weren't exactly surprised—more dazed, as if they had just awakened from a bizarre dream and hadn't quite figured out where they were. A few still looked openly skeptical, but even those looks faded as Weiner droned on about parallel universes and anomalous nuclear decay rates.

By the time Randy showed the audience a copy of the message, the reporters had recovered enough to start shouting out questions.

"Are you saying that this message was sent by *aliens?"*

"All we know for sure," said Balusu, "is that such a graviton beam is well beyond our—"

"Aliens from another *universe?* Are you *nuts?"*

Suddenly they were all on their feet, clamoring to be recognized. Kernighan rose as well, but her voice couldn't be heard over the din. Weiner came to the rescue. "Ladies and gentlemen," he roared, his face red, his white hair frizzed out around his head like a low-rent halo. "No, we most certainly are *not* nuts."

One at a time, the reporters seated themselves. "Please," said Kernighan. She ran a hand through her sleek cap of red hair, leaving it mussed. "We are trying to explain."

"But—what do they look like?" The lone voice sounded wistful.

"What do they want?" said another.

Randy cleared his throat and glanced sidelong at Alex. He seemed shaken. "We—we've only received one message. It's almost certainly a cartoon of the LIGO facility, and the symbols here and here are very simple math and mechanics primers, so that we could understand these instructions, here."

Dead silence. "Instructions?" asked one reporter quietly. Alex wondered if Rosenthal perhaps had a point.

"Instructions to build a very large pendulum, in the middle of the square defined by LIGO's two arms."

"A pendulum?"

Randy nodded. "A pendulum. We've been working double shifts these past weeks, and the pendulum is almost complete. It swings a 120-pound lead sphere with a 5.5 second period. The length of the pendulum, as specified in this message, is somewhat adjustable via a large motor. In a few hours, once we connect the LIGO signal to the motor, whoever is talking to us will be able to exert some limited control over the period of the pendulum by varying the strength of their graviton beam. In this fashion, they can send us messages."

"They're sending messages now." Alex winced; the voice was Rebecca's. "What will this pendulum buy them that they aren't already doing?" Sure enough, there she stood in the back of the room, taking matters into her own hands.

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Rosenthal's eyes were fixed on Rebecca, his jaw set. "No comm—" began Randy.

Alex interrupted him. "The pendulum is almost certainly meant as a poor man's transmitter. We have no idea how to make a graviton beam to communicate with the senders, but from this message it's clear they can 'see' some of our Universe, probably from gravitons scattering back into theirs. So if we can change the period of the pendulum as they watch, we can talk back to them."

Rebecca moved forward to stand behind the last row of seats. A camera flash strobed. Rosenthal looked increasingly grim. "Then why hook up the pendulum to the LIGO signal?" Rebecca asked. "Why don't we drive the motor ourselves?"

"Presumably they will send us some sort of primer," Balusu ventured. "There are many ways to encode information. They will tell us which one they prefer."

"If they're smart enough to do this in the first place, they can decipher any kind of message *we* could send—"

Rosenthal turned to whisper in the ear of a Hanford security guard, and Alex cut Rebecca off. "Currently all we have to go on is one message, and this is what they asked for. It seems fairly innocuous. I'm sure they'll explain further when it's time."

Rebecca locked eyes with him, a slight frown furrowing her brow. Alex held his breath—as usual, she didn't understand the trouble she was stirring up. Nor did she see the guard poised to escort her out. With a frustrated shake of the head, Rebecca left. Reporters scribbled madly, Weiner continued his spiel, and Alex tried to decipher the expression on Rosenthal's face.

It was almost nine by the time Rebecca returned to LIGO. She hadn't seen Alex since the press conference; she'd been busy coping with the enormous spike in traffic on the Hanford site when the news hit. And now she couldn't decide whether she'd be happy to see him, or whether she'd read him the riot act about cutting her off. Dammit, those were good questions. Even Rosenthal had to realize she wasn't the only one who would come up with them.

She swiped her new badge through the new high-security CAIN booth, typed in her passcode, and reached for the door to the control room—just as her cell phone rang.

"Aunt Rebecca?"

Not now. "Stacia. Isn't it past your bedtime?"

A hurt silence, and Rebecca realized she hadn't done a very good job of keeping her impatience from her voice. Nor, she had to admit, had she tried. "I'm sorry for snapping at you, honey. Is something wrong?"

"Mommy said to tell you that if you don't come home and take care of Ellery I get to keep him. Can I really have him?"

Rebecca sighed. Her schedule had been so crazy the last few weeks that she'd been leaving Ellery with her sister. Apparently Bobbie had had enough. "No, honey. Your mommy's just mad at me for not taking better care of him. Tell your mommy I'm sorry. I'll be home soon. I just have a few more things to take care of."

With a promise to go right to bed, Stacia hung up.

Rebecca took a deep breath, resisted the urge to fuss with her hair, and slipped into the control room. Everyone looked up, including Alex, but they all seemed subdued. Alex approached her, his expression stony.

"You shouldn't be here."

"Excuse me? I was invited, remember?"

"That was before Rosenthal clamped the lid down on us again. He's classifying everything he can get his hands on. He says it'll be released when he's determined it's not a 'threat to national security'," Alex mimicked in savage tones, "but who knows how long that will

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take? He's bringing in his own cryptoanalysts, and probably his own team for the pendulum." Alex shook his head. "This is *no* way to do science."

"How can he classify everything if we've just made a public announcement?" Rebecca demanded. Alex shrugged and turned away. "We'll fight him. This is public knowledge, now. When the Whos' messages aren't released the public will want to know—"

"Rebecca, haven't you done enough?"

Rebecca froze, cheeks burning as though she'd been slapped. "You think this is *my* fault?" She turned away, feeling sick. "I'd better go."

"No." Alex took one step closer, then another, then touched her arm. "No. Don't go. I—while you're here, I may as well show you the latest." He motioned to five monitors, four of which showed bright laser spots, and another that flickered sporadically. The interferometer, still at work. "The original message stopped as soon as we hooked it up to the pendulum," Alex said. "Then it looked like the Whos were just toying with the pendulum—driving it with a periodic forcing function and pumping up the swing amplitude. Then, about twenty minutes ago, the signal doubled in size. But from what I can see, there's no obvious signal pattern."

The door behind them burst open and Rosenthal entered, followed by Kernighan and two Hanford security guards—one of whom looked all too familiar. It was the guard who had harassed her on Highway 240. His face remained expressionless, but his eyes tracked her as he marched past.

"Alex," snapped Kernighan. Normally polished and self-assured, she now seemed under rigid control, her jaw tight, her face pale. "Where's Weiner?"

"His office, I think," said Alex. He looked from Kernighan to the guards to Rosenthal, bafflement plain on his face. "Why? Now what?"

"There's—" Rosenthal raised a hand and Kernighan shook her head. "There's been a . . . an incident. I'm shutting LIGO down."

"What?" Weiner, emerging through the door leading to the offices, hurried to join them.

"What sort of incident?" Alex asked.

Kernighan studied first Alex, then Weiner. "Twenty minutes ago two of the new reactors at the Columbia Generating Station went down."

"Dr. Kernighan, may I remind you—"

"Mr. Rosenthal. May I remind *you* that these are the only people who have a hope of solving this?" She turned back to them as Randy and Joe joined the group. "Northwest Energy said that several safety interlocks cut out at the same time, and now it looks like the piles are barely even radioactive. I'd say that sounds like your Zeno effect."

"Columbia Generating Station?" Alex repeated. He was starting to look punch-drunk.

Rebecca touched his arm. "The three nuclear reactors across Route 4," she said. Alex stared at her, then at the other LIGO team members. "Just northeast of here."

"Northeast? But the beam goes northwest. . . ." Randy's eyes widened. "It's *another* graviton beam? But even so, the reactor should still work. If it's just the radiation readings—"

Kernighan silenced Randy with a raised hand. "I'm under orders to shut you down until everything returns to normal."

Weiner froze as everyone—including the Hanford guards—turned to stare at him. His gaze shot from Kernighan to his subordinates and back, and judging by the expression on his face he was trying to decide whether jumping from a five-story building would be less painful than climbing a razor-wire fence. Finally he took a deep breath and drew himself to his full height. "I'm sorry, Marjorie," he said. "LIGO isn't a DoE project, and you can't shut me down. And neither can you," he snapped at Rosenthal.

Rosenthal eyed Weiner coolly. "No,

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but I know who can. Let's go make a phone call."

As they left, Hanford guards in tow, Alex dropped into a chair and motioned Randy and Joe over. Rebecca perched on the edge of the desk, just outside the huddle. "Time for some fast thinking," said Alex. "What the hell is going on?"

"Another graviton beam," Randy repeated. He sounded dazed.

Alex nodded. "That explains the doubled signal. But why? If they're trying to double the amount of information they're sending, we'll *never* understand them."

"Both horizontal directions are inefficient to begin with," said Randy. "If the Whos had wanted a bigger signal they should have sent the beam in vertically."

"Not if they're sending two separate tracks of information."

"Wait." Rebecca raised a hand. "Why can't we understand what they're saying?"

"LIGO's still seeing just one signal, so the two beams must be at the same frequency. All we can measure is the sum of the two beams. Even if there's info in each of them, we can't separate the signals."

Rebecca raised an eyebrow. "I think several dozen Hanford employees who spent a week out in the desert with radiation detectors would beg to differ with you on that."

Joe grinned, while Randy laughed aloud. Alex blinked at her. "You are a genius," he murmured, then turned to the other two. "She's right. We put a radioactive source in each beam, and look for fast decay fluctuations from the Quantum Zeno Effect. Now that we know they're gravity waves, we don't really need LIGO at all."

"But Alex, if we don't need LIGO, why all this pendulum business in the first place?"

Alex studied her, his expression grim. "It's a good question, Rebecca. But you shouldn't have asked it during the press conference."

"When *should* I ask it? When I have Rosenthal's okay in triplicate? *That's* no way to do science."

"There's no science at all if he won't let us see the data," Alex snapped.

"So you're giving up? You're just going to let Rosenthal tie your hands?"

Total silence. Randy examined his fingernails while Joe watched the monitors. Alex studied her, eyes narrowed, face expressionless, and Rebecca wondered if she'd finally gone too far. When he spoke again, both Randy and Joe jumped.

"We still have one hand free. I'll call Steve—he'll be able to help set up the sources in the beams. For whatever reason, turning on the pendulum has gotten them to change the message, so I think it's important that we keep it operational—"

Weiner entered, pale and shaken. He was followed by Kernighan, who looked pained, and Rosenthal, who looked smug. Rebecca nudged Alex. "Too late," she whispered.

Weiner cleared his throat. "I have been directed to shut LIGO down immediately."

Alex thrust himself to his feet. "Patrick, you can't. We know how to—"

Weiner raised a hand. "I'm sorry, Alex."

Randy glared at Weiner across the room. "Great. Now the pendulum will stop working, and the Whos will know."

"And then what?" asked Rebecca. "They go back to Whoville?"

"Possibly. I'm guessing we could be down for a long time."

Across the room, Weiner was already dropping the laser out of lock. Bright circles disappeared on two of the four primary monitors.

"Clock's ticking," muttered Randy.

"We could send the Whos a message," whispered Joe. "With the pendulum. If DoE is so worried about the nuke plants, we tell the Whos to flip the second graviton beam around. It won't hit the reactors if the beam goes southwest

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instead of northeast. We can draw a little binary cartoon—"

"I'll deal with the pendulum when I've secured the interferometer," said Weiner loudly.

"Or maybe not," Joe finished.

Alex's eyes met Weiner's across the room. "Yes, we can. We just have to get there first."

"My car's in the front parking lot," whispered Rebecca. She slid a hand into her purse, but Alex stopped her.

"They'll never let you through the perimeter."

"We still have to *try*."

Alex's gaze remained steady. "No, we don't. We're *already* inside the perimeter. This building is the corner of the square. And my bike is in my office."

Randy grinned. "You can cut through the lab! Joe, start working on that cartoon."

Rebecca turned to Randy. "Go help Weiner think of creative ways to secure the interferometer." Randy nodded. "I'll start emailing all my press contacts—get the word out about what's happening here."

Alex grabbed his saddlebag. "I'll call when I get to the pendulum," he told them, already on the move.

"Be careful," Rebecca whispered, but Alex didn't seem to hear.

Alex knew he was violating at least four clean-room rules just by riding a bike through the Laser and Vacuum Equipment Area. He had even forgone the mandatory booties, pausing at the entrance only to don his laser goggles.

He ducked under the vacuum beamline, habitually closing his eyes as his head passed through the plane of the laser, and pulled his bike underneath. The tires left a faint mark on the floor, and he winced, reminding himself to clean it up before it destroyed their ultra-high vacuum at the next vent.

Alex had planned to disable the interlock on the rear exit, but someone had already removed the magnetic sensors. He pushed the rear exit open and squeezed his bike out into the cool desert night. The shortcut had put him on the inside of the interferometer arms, with a straight shot out to the pendulum. Anyone going out the main exit would have to loop around and take the access road over the northwest beam tube.

His optimism faded as he realized what sort of surface he'd have to bike on. From a distance, the area looked like smooth grassland with an occasional mound of scrub. Up close, it was uneven and pitted with rocks. He veered toward the road. It would make for smoother biking, but it was also the route Rosenthal would take to the pendulum. Alex took a deep breath and pictured himself in the Hanford 500.

As he pedaled, Alex calculated the distance. LIGO formed two sides of a 4km square, and the Whos had asked for the pendulum to be built in the exact center. So 2km times the square root of two . . . almost two miles. Sure enough, Alex soon saw the lights atop the barbed wire fence that surrounded the pendulum. As he approached the gate, he saw a figure waiting for him. Alex breathed a sigh of relief when he saw it was Balusu, the SETI guy.

"What is happening?" Balusu asked him as he dismounted. "The LIGO signal is dead."

"There's another graviton beam," Alex huffed, as he trotted toward the pendulum. "It shut down some nuke plants. Weiner was ordered to turn everything off." Two big breaths. "We have to get a message out or the Whos may give up."

"But we have no approval for an outgoing message," Balusu said. "I should check with Mr. Rosenthal."

"No! Please, trust me on this one. I'll be responsible for whatever happens." Alex handed Balusu his bike. "And if Rosenthal shows up, hold him at the gate." He darted into the building.

The pendulum towered in front of

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him, the lead sphere dangling motionless from its twenty-five-foot cable. The cable looped through a complicated pulley system to an industrial-strength motor. A few grad students from LIGO milled about, lost without Balusu to direct them.

"Someone show me how to control the motor—and get that ball swinging again," he ordered. He was surprised at his take-charge tone of voice, but even more surprised when the grad students obeyed. Alex pulled out his cell phone and punched in the number for the control room.

Joe answered on the first ring. "Okay," he said. "I've squeezed it into an eight-by-eight picture, but that's still sixty-four bits we have to send, and we should probably send it at least twice. It's a binary picture—we can use a short period swing for a 1, and a long period swing for 0. And you'd better hurry—Rosenthal's coming and he wants your head."

"Okay, give me the sequence." He scrawled down the ones and zeros as fast as he could, then signaled for the sphere to be released. "Three zeros then a one," he told the student helping him with the motor. "That means three full swings, and then shorten the cable." The motor came to life at the proper moment, the cable shortened by about a foot, and the frequency of the swings went up a small but noticeable amount.

"We're doing it!" said the student excitedly. "We're really talking to them!"

"Shh. Don't lose count." Alex glanced at the entrance to the building, hoping Balusu would hold his ground.

At every moment Alex was sure guards would come storming through the door, but they made it through forty swings, fifty, sixty, then readied for the final motor run. Bit sixty-one was a zero, but sixty-two to sixty-four were all ones. "Shorten the cable . . . now!" The cable contracted, and swing sixty-two began.

"That's it!" shouted Alex encouragingly, but Joe was right—there was no guarantee that the Whos would figure out this was an eight by eight picture if he didn't at least repeat a decent portion of the message.

Then all hell broke loose.

"There he is!" shouted Rosenthal from the door. The Hanford guards followed, one shoving Rebecca ahead of him. She stumbled and Alex lurched forward, torn between going to her and staying with the pendulum. "Get him," said Rosenthal, "and stop that pendulum."

The sixty-second swing reached the end of its arc.

Alex raised his hands in the air. His mind raced; he'd never repeat the message now. But maybe if it stopped after *exactly* sixty-four swings. . . .

"Sixty-three," intoned the student. "Looks like those guys are gonna stop it here, though." He was right; the two guards had enlisted the other grad students and were preparing to latch the pendulum as it finished the sixty-third swing.

"Just let it swing one more time!" he cried. "Please!"

They were ignoring him, readying the latching mechanism. The sixty-third swing was finishing, the lead sphere slowing down as it approached its terminus. . . .

Rebecca tapped her favorite guard on the shoulder. He looked around, startled, and she smiled. "I've been meaning to do this," she said, and punched him in the nose.

The second guard grabbed Rebecca. The grad students, entranced by the drama, missed the sphere entirely. The sixty-fourth swing commenced, but Alex only saw Rebecca and her grimace of pain as the guard jerked her arm up behind her back. "Hey," he yelled, hurrying towards them, "Leave her alone—"

"Catch it," Rebecca said, as the first guard intercepted Alex with a palm to his chest.

"You heard her," Alex coughed at the students, who eyed each other, then turned back to the pendulum and

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caught it with anticlimactic ease.

"Well." Kernighan stood in the doorway, a wry smile on her face. Weiner peered over her shoulder, while Balusu danced on the outskirts. "You sent your message. Now what?"

Alex cleared his throat. "We've told them to swing the graviton beam around, so now we wait to see if the reactors come back up."

"No," Rosenthal snarled. He jabbed at Alex with a forefinger. "You two are coming with me."

"Actually," said Kernighan, "I think Dr. Chow had it right the first time. Now we wait to see if the reactors come back up." She locked eyes with Rosenthal, who stalked toward her, his face reddening.

"This is a matter of national security—"

"Oh, bullshit. These kids were just doing what we should have done in the first place." Kernighan studied Rosenthal, her face somber. "Use your own goons. These guards are mine."

"But ma'am—" said the first guard, lifting a hand to his nose. A trickle of blood stained his close-cropped mustache.

"Break my heart. Let them go, or you're on permanent tumbleweed detail."

The guards reluctantly stepped back, and Rebecca flew into Alex's arms. Kernighan nodded to Rosenthal. "It'll take a while to wake up everybody you need to get me fired. You'd better get busy."

Rosenthal, his face as gray as his suit, shoved past her and out the door.

Kernighan watched him go. "You know," she said to no one in particular, "I'm surprised that any intelligent race—anywhere—would want to help *us*."

Rebecca stiffened in Alex's arms. He looked down. She was gaping at Kernighan as though the DoE woman had just divulged the secrets of the Universe. Kernighan didn't seem to notice as she waved them toward the door and said, "Let's go back to LIGO. I suspect we'll have a bit of a walk."

Rebecca stayed in the corner of the LIGO control room and watched in silence, wondering what, if anything, she should say.

The call had come through; both nuclear reactors were back to normal. The news sent Weiner's team scrambling. Most of the jargon was incomprehensible, but she understood the word "lock," and the congratulatory back-slapping that accompanied it. Ten minutes later, Alex dropped into a chair next to her, a happy, exhausted grin on his face. He took her hand. "I'm glad you're still here."

"I wanted to tell you how proud I am of you."

He grinned. "Aw, shucks, ma'am—"

"And I need to talk to you."

His eyebrows shot up. "Is—everything okay?"

She squeezed his hand. "Everything's fine. I had an idea, and I decided to run it past you first instead of broadcasting it to the entire world. For once."

Alex grinned. "Sure. Shoot."

"Not here. I have a blanket in the car. Let's go outside."

Alex shrugged. He seemed content to hold her hand. "Sure. I could use the fresh air."

It was very late; the desert night was cold, the stars brilliant points of light crowding the night sky. Rebecca fished a wool blanket out of the back seat. "It's covered with dog hair," she said, "but if I reverse it we shouldn't get too shaggy—" She backed out of the car and straightened. Alex put his arms around her and kissed her.

When he finally pulled away with a muffled, "Let's get that blanket around you," Rebecca didn't know how she could feel so warm and still be shivering so hard. "How can you worry about dog hair," Alex continued, "with everything that's happened tonight?" He wrapped the blanket around her shoulders and joined her in its circle of warmth. "To-

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morrow, first thing, I'll talk to Steve about setting up radioactive sources in the beam—"

"You won't be able to understand them." Rebecca wondered if Alex could understand *her*, the way her teeth were chattering.

"What?" He wrapped his arms tighter around her. "Rebecca, what's wrong?"

"We won't be able to understand them. At least not at first."

"What are you talking about?"

"It's just an idea, but it fits. It all fits. Why the Whos want us to use a pendulum, and why they're bringing in the beams horizontally, and Stacia on the phone—"

"Whoa." He led her to a bench next to a display consisting of a section of beam tube set in concrete. Visible through the other end was an arc of stars above Rattlesnake Mountain. They sat on the cold wood. "Okay. Start again. Slower this time."

Rebecca took a deep breath. "Kernighan gave me the final piece. She wondered why the Whos should help us. That's a very good question." Alex pulled away and she could feel him staring at her. "You know, my sister is the best mom in the world, but she's also a smart woman, and sometimes she's starved for adult companionship. Intelligent conversation."

"What are you saying?"

"Why have us build the pendulum when they can communicate with us directly? Why have us repeat everything they say? Is there someone out there they *can't* communicate with? Stacia gave me a message tonight, a message from Bobbie that she wouldn't, or couldn't, say herself. And I gave Stacia a message for Bobbie. Maybe that's what we're doing with the pendulum. Acting as a kind of go-between."

"Between who?"

"Between Whos."

Alex sucked in a sharp breath. "Randy talked about the possibility that there's a whole series of universes, stacked up in some fifth dimension. He said that it didn't matter, because we could only talk to our direct neighbors anyway."

"So let's play 'what if'," Rebecca said with a smile. "What if the Whos on one side want to talk to the Whos on the other, but our Universe is in the way?"

He looked thoughtful. "If they both can watch our pendulum, and they both can send one of the beams, that would be all they'd need to communicate." Alex's fingers dug into her shoulders. "That makes us nothing but a *relay* station."

"No, no—we're children." Rebecca laid her palm on his cheek and searched for his eyes in the dark. "Look at Stacia. She knows I hate being called Becky. Did I tell her that? No. She figured it out for herself, and a hell of a lot more, by watching, listening, observing. That's what children do, and that's what we have to do. The Whos *want* us to listen. That's why they're using horizontal beams, so we can set up our detectors and see what they're saying to each other."

"That's quite a theory. I guess we'll know soon enough." Alex relaxed against her with a bone-deep sigh. Then he laughed.

"What's so funny?" Rebecca asked, pulling away.

"Rosenthal," Alex said. "He's fenced off and classified the one point where he *can't* get any information. Where the signals are hopelessly mixed."

Rebecca chuckled. "And meanwhile we'll put detectors in both beams and listen to our hearts' content."

Alex pulled her closer. "Each detector will be a two-person job, you know. We'll have to set up a little tent, find some way to keep warm on those cold, cold nights. . . ."

"Oh, Alex," she said as he leaned forward to kiss her again. "Grow up."■

—The authors would like to thank Mike, Katie, and Amanda White for their invaluable assistance with this story.

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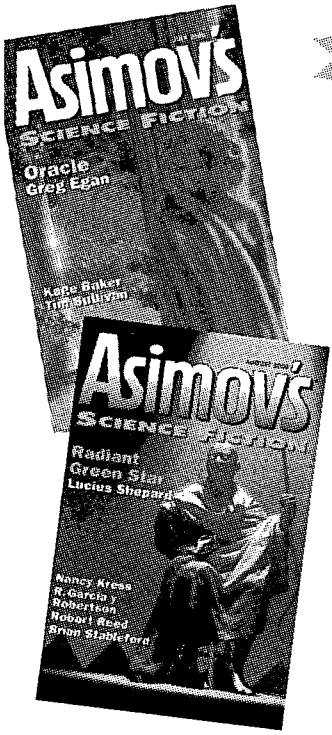

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The Sky So Big and Black, John Barnes, TOR, $24.95, 317 pp. (ISBN: 0-765-30303-5).

The Duke of Uranium, John Barnes, Warner Aspect, $6.99, 291 pp. (ISBN: 0-446-61081-X).

A Mouthful of Tongues: Her Totipotent Tropicanalia, Paul Di Filippo, Cosmos (Wildside), $29.95, 180 pp. (ISBN: 1-58715-506-0).

Kingdom of Cages, Sarah Zettel, Warner Aspect, $7.50, 589 pp. (ISBN: 0-446-61106-9).

Enoch's Portal, A. W. Hill, Champion Press (www.championpress.com), $25, 267 pp. (ISBN: 1-891400-58-4).

Swan Songs: The Complete Hooded Swan Collection, Brian Stableford, Big Engine, £16.99, 647 pp. (ISBN: 1-903468-04-3).

The Fantasy Writer's Assistant and Other Stories, Jeffrey Ford, Golden Gryphon, $23.95, 248 pp. (ISBN: 1-930846-10-X).

Strange But Not a Stranger, James Patrick Kelly, Golden Gryphon, $25.95, 297 pp. (ISBN: 1-930846-12-6).

The Great Escape, Ian Watson, Golden Gryphon, $23.95, 283 pp. (ISBN: 1-930846-09-6).

The Sir Arthur Conan Doyle Reader: From Sherlock Holmes to Spiritualism, Jeffrey Meyers and Valerie Meyers, eds., Cooper Square Press, $28.95, 500 + xxxvi pp. (ISBN: 0-8154-1202-9).

John Barnes has a couple of interesting series going. The last entry in the "springer" series was *The Merchants of Souls*, praised here last June. Now we have **The Sky So Big and Black**, third in the "meme war" series that began with *Kaleidoscope Century* (reviewed here in November 1995) and continued with *Candle* (reviewed May 2000). The basic idea—strange though it may seem—is that in the not-too-distant future someone will figure out how to make a computer virus that can adapt itself to any operating system. Before long, it turns out that the human mind is just another OS, and if the virus can just get in, you become its puppet.

I suppose that's not so bad if all you then do is wander around endlessly repeating something like "Have a nice day!" Advertising agencies would surely love that. But of course people have to "improve" the meme virus until soon there are a variety of them competing for space in human minds, running recruitment campaigns, and waging war against each other's armies. The result is pretty Darwinian, and in due time one meme-virus, known as "One True," conquers all. Everyone on Earth is infected by a milder version called "Resuna," and Earth is ruled by a cooperative, industrious hive mind busily repairing the damage done to infrastructure and ecosystems by the meme war.

Fortunately, not all of humanity was

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on Earth at the time. The colonies on the Moon and Mars escaped the disaster and were even able to absorb hordes of refugees. They even developed ways to detect and deactivate Resuna, one of which centers on special cops ("shrinks") who watch for signs, get the infected to talk their memories onto tape, and then wipe their memories to get Resuna. This tends to damage the personality as well, of course, and the damage is not undone when the patient watches the tapes to regain at least weak versions of the removed memories.

So meet Terpsichore Murray, right on the cusp of adulthood. She's an eco-prospector, hunting water and methane deposits with her dad. And she's just a tape in the shrink's office, where he is reviewing the evidence, worrying, and drinking himself blind.

Teri's a nice kid. Smart and industrious and responsible. As Barnes reveals how his shrink works, we know something awful is about to happen. But first Barnes shows us how well he can do a teen girl as he lays out a fascinating Mars (you don't walk—you "roo") and a satisfying occupation (ecoprospecting). Teri and Dad have just made a big hit—they're rich! She has a guy—except that's about to crash. She's about to take the Full Adult exam—and that's a grand success. And now she and Dad are setting out to lead a passel of kids cross-country to school.

Except that the Sun has just burped. A massive flare fries most electronic circuitry. Dad is dead. So are a couple of kids. Suits are damaged. The radios are useless. It's up to Teri to get the survivors home safe—if she can.

Meanwhile, watch that shrink. Another shrink has showed up to give him a hand. Except that weeks are suddenly missing from his memory. Has he been dememed? How'd he get infected? All he's been doing is watching Teri's tapes!

You think I'm going to spill the beans? Nah. Just bear in mind that Resuna's pretty clever and like the Devil, can wear a fair face. Barnes is clever too, so you'll enjoy finding out what happens.

Have fun!

In another mode entirely, Barnes gives us **The Duke of Uranium.** When Jak Jinnaka's girlfriend is kidnapped by the mysterious Duke of Uranium, Jak must discover that his world—beginning with his home in the Hive space colony but hardly ending there!—is a maze of plots and cabals, and then he must somehow track down the Duke and rescue the lady.

Good, fun space-opera.

The writing is so lush that one wishes Paul Di Filippo would reread his Strunk & White, but **A Mouthful of Tongues: Her Totipotent Tropicanalia** is nonetheless worth the buying for its phantasmagorical, sensual imagery and offbeat eroticism. It's magic realism with vim and vigor; if you're too old to enjoy it, try reading it on Viagra.

The protagonist is one Kerry Hackett, who works for Diaverde, a bioengineering firm presided over by Peter Jarius. Her initial dream—fever-heated, fecund jungle, jaguar, bestial climax—segues into waking beside a virus-infected, boneheaded lover, going to work through an urban jungle stalked by soldiers armed with sleek rifles and peopled by panhandlers wrapped in greasy blue blankets, and confronting a boss who shows her the grandest marvel of his labs, a creature called a "benthic," and puts a very heavy make on her. She flees, is raped, and runs to the lab, where she lets the "exogamically desirable" benthic touch her.

Instantly, it invades her body. She is transformed into a protean creature of enormous erotic talents. And off she goes to Bahia, the jungled land of her dreams (marred by Di Filippo's belief that lemurs are to be found in Central or South America). Her abilities become manifest: She can launch her tongue to subdue a foe, and promptly generate a

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new one (*vide* the title). She can change the form of body parts to either erotic or deadly effect. And she can heal—indeed, she becomes known as a bruja, a witch, when she causes a man's missing arm to regrow. Not surprisingly, the local gangster chief finds her an object of desire, but justice is served as Kerry takes her talents over the top. Then it's up to a local tribe to bring her to rein.

Where is Jarius while all this is going on? There's not a sign. Di Filippo focuses entirely on his heroine and quite ignores the frantic hunt for the missing benthic that must be going on. Or does he? At the very end there is a hint that Kerry's jungle adventure is nought but a dream (which would explain the lemurs).

Except . . . There is justice yet to serve, and for a clue I will only remind you that the name "Jarius" has a certain biblical connection.

The title and cover of Sarah Zettel's latest, **Kingdom of Cages**, make one think of a place where people are kept like budgies in small enclosures, free only to perch, flutter, and sing. Yet—since the cover makes no mention of conquering aliens—who could put humanity in cages except humanity itself?

It doesn't take long before one realizes Zettel is not quite being that literal. Yet there is a parallel. Humanity has pretty well destroyed Earth's natural ecosystems. The old home world is bursting with people, every scrap of energy and greenery managed for human benefit, and it has long since put its spacegoing ambitions behind—though not before casting forth its spawn in the form of the Authority, a system of technically sophisticated space-based cities that coordinates the Called (colony worlds settled by intolerant splinter groups, some as small as a hundred people) and the Shippers (family groups whose ships link Authority and Called).

There is also Pandora, which chose long ago to remain aloof from the rest. The Pandorans' mission is to understand their world, the most Earth-like of all those found so far. They therefore drastically restrict their interaction with it. Its masters, the Hothousers, live in domed cities overseen by AI cityminds and are themselves equipped with implanted Consciences that enforce proper behavior and orientation. The villagers—descendants of a few colonists once permitted to land—are property, experimental subjects (the Hothousers go in for genetic engineering, though Zettel never shows us anything remarkable for results), confined by fences that deliver painful shocks to those who attempt to stray.

And now the Diversity Crisis has struck: The Called are dying, suffering from inbreeding, inadequate attention to infrastructure, depleted local ecosystems, declining fertility, rising birth defects, and plagues galore. The Authority and Shippers are alarmed, for their livelihoods depend on the Called. This is why they are telling the Pandorans: "Use your vaunted understanding to find a cure for the Crisis, or we will destroy your ecological treasure."

It doesn't seem difficult to come up with an answer. If Earth can survive all its mistakes, there must be some security in numbers (no inbreeding, anyway), as well as being in one place (fewer diseases to come to terms with). But the Called are intolerant, even *in extremis*. No way will they share a world with all those scum out there! Not unless the situation grows so desperate that there truly is no other option.

So the story opens. Athena Station, orbiting Pandora, is growing crowded with refugees. A few, such as Helice Trust and her daughters Chena and Teal, are permitted to come down to Pandora and settle in a village. But there is apparently something special about the Trusts, for they have attracted the attention of Dionte, a researcher frantic for an answer to the Crisis, and almost from the moment they set foot on Pandora,

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Helice is being offered a comfortable life for herself and her girls if only she will volunteer to become an experimental subject. Dionte's brother, Administrator Tam, seems to be trying to protect them.

Why? That will not be clear for years. First, the conditions of life for the Trusts must grow worse, even as Chena proves to be extraordinarily enterprising and Teal shows herself to be an unyielding brat. Helice must yield, let herself be impregnated, and die most bloodily. Dionte must show herself a schemer without compare, clever enough to find ways to manipulate both the Consciences of her fellows and the mind of her city. And the Diversity Crisis must grow worse.

Zettel has established herself as a thoughtful, ingenious writer with *Reclamation* (reviewed here June 1996), *Fool's War* (May 1997), *Playing God* (November 1998), and *The Quiet Invasion* (September 2000). She is still good, excellent with character and plot and scene, but here she has given herself a simplistic, unlikely set-up. If we ever establish interstellar colonies, they will surely encounter problems. But I doubt they will experience simultaneous catastrophes like her Diversity Crisis, lacking an outside precipitant.

Is science fiction always supposed to be "likely"? Well, no, despite the opinions of snotty reviewers. It can also use the tropes of the genre as metaphors for life and humanity, and this is surely Zettel's game. She is saying that we are doomed if we lock ourselves away in little boxes, physical or mental, and of course she is right.

But I *do* wish her set-up didn't feel so much like a put-up.

A. W. Hill has been a musician, composer, "dabbler in arcana," and Disney music executive. His first novel, **Enoch's Portal**, is "in development as a motion picture," and he's been pushing it at every reviewer in sight, complete with a packet of press releases and clippings about what a great thing he's done.

Not that that's bad, you understand. Publicity is the name of the game, after all, but when it's dished out with a heavy hand, the reviewer gets a mite irritated and eventually picks up the book with just a bit of a chip on the shoulder: "Okay, so show me . . . I dare you!"

It doesn't help when said reviewer quickly finds such awkward writing as "Sofia glided down the . . . street . . . Anyone watching would have described [her] movements as gliding . . ." But I kept on reading anyway, and once Hill picked up the momentum, the novel turned out to be a pretty decent action yarn.

The hero is Stephan Raszer (rhymes with laser), a private-eye *cum* shaman who emits gnostic light beams from one eye (*vide* Philip K. Dick's *Valis*) and specializes in the realm of strange groups such as the Solar Temple and Heaven's Gate cults, known for staging mass suicides as a way to ascend to heaven, or Sirius, or wherever. Indeed, Raszer is called in by a Hollywood exec to retrieve his trophy wife from The Temple of the Sun, lately known for mass suicides. Disguised as a cult witness for the next sacrifice, he heads for Prague, where he discovers he is now deeply embedded in a vast, age-old conspiracy of Rosicrucians, Knights Templar, Swiss Gnomes, crypto-Nazis, and other Illuminati (*vide* the works of Robert Anton Wilson). Sofia—the wife—seems doomed, but Raszer connects with a kabbalistic rabbi and despite numerous wounds at the hands of a murderous foe, yanks her back from the brink, only to have the plot swerve desperately into the Australian Outback for a showdown at Ayers Rock.

So it's mystic conspiracy fantasy, with a thoroughly bewildering mishmosh of bafflegabs, and maybe it's just your cup of tea. But I suspect the movie will be more entertaining.

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* * *

Back in the seventies, when DAW Books was new and looking for authors, Brian Stableford published a series of novels—*Halcyon Drift*, *Rhapsody in Black*, *Promised Land*, *The Paradise Game*, *The Fenris Device*, and *Swan Song*—in which he tried to find for himself a more successful narrative voice, discover a way to tell a nonviolent space-opera, and escape the counting of grain beetles. *Halcyon Drift* remains Stableford's most successful single novel, and the series, he says, was instrumental in changing his career path. Checking my shelves, I even find three of the old DAW paperbacks, two of them with nice Kelly Freas covers and all with fond memories attached.

You can find all six of the novels in **Swan Songs: The Complete Hooded Swan Collection**. The protagonist, Grainger, is a wisecracking anti-hero who, forced to pay off the cost of his rescue from years marooned in space by laboring as the pilot of the *Hooded Swan*, a brand-new sort of starship, hies off to adventure, complete with his alien mind-parasite.

You should not take the simple fact that Jeffrey Ford's *The Physiognomy* won the 1998 World Fantasy Award as a sign that he writes conventional fantasy concerning elves and dragons, armored knights and talking pussy cats. He doesn't. He is more like, perhaps, Avram Davidson, or Michael Swanwick, who wrote an effusive introduction to **The Fantasy Writer's Assistant and Other Stories**.

Most of the tales herein displayed are from small press magazines such as *Black Gate*, *Aberrations*, and *Northwest Review*. Their imagery is of fly-fishing for bats, brains in jars, bark monsters named Cavanaugh, a whippet named Mathematics, strangeness and insight, and awed pleasure.

Enjoy.

* * *

The last James Patrick Kelly book I reviewed was *Wildlife*, way back in July 1994. That was a set of four connected novellas, the first of which was "Prisoner of Chillon," which introduced Wynne Cage, clone of Tony, in 2044. She's a photojournalist accompanying a hood on a heist of valuable software from an orbital research station. After an exciting flight for safety, they wind up in the castle of Chillon, guests of the cripple Bonivard, who depends on robotic prostheses for mobility and is delighted to find that the software macguffin, called "Wildlife," is designed to make it possible to copy a human mind into a computer. Here is a way by which he might escape the chains of his handicap. The chains of the past are another matter.

Then there was *Look into the Sun* (reviewed here in November 1989), which grew from the novelette "The Glass Cloud" concerning an architect hired to build a tomb for an alien goddess.

Strange But Not a Stranger includes both "Prisoner of Chillon" and "The Glass Cloud," along with thirteen more, mostly from the major SF magazines, and all well worth your attention.

Ian Watson has for many years been one of Britain's prominent contributions to science fiction. He also worked with Stanley Kubrick and Steven Spielberg on the story for the movie *A.I. Artificial Intelligence*.

The Great Escape showcases his recent short fiction, including a very nice report on how to kill a vampire with sweetness ("My Vampire Cake"). And in the introduction, he tells us a bit about the *AI* movie and wonders whether future AIs will "feel a need to tell stories? And what might their stories be?"

That's a good question, but for now we must be content with wondering what Ian Watson's stories might be. Fortunately, he has given us this collection so we can find out.

Sir Arthur Conan Doyle is best known

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for the Sherlock Holmes canon (which—building on Edgar Alan Poe's work—created the modern mystery genre) and *The Lost World* (progenitor of *Jurassic Park* and *Dinotopia*, etc.), but he also wrote sports stories, horror, historicals, travel reports, propaganda, and puffery for the table-thumping spiritualists of the time. For samples of the full breadth of the Doyle career, see **The Sir Arthur Conan Doyle Reader: From Sherlock Holmes to Spiritualism**. In their introduction, editors Jeffrey Meyers and Valerie Meyers review the Doyle life and consider the impact Doyle had on his contemporaries. For instance—in the "I bet you didn't know" department—P. G. Wodehouse was an admirer of the Sherlock Holmes stories and deliberately modeled his renowned chucklehead Bertie Wooster and the shrewd butler Jeeves as comic variants of Watson and Holmes.

One element of the book is timely. For the past few years, the news has been full of stories about slaughter, rebellion, and general upheaval in the Democratic Republic of the Congo, once known as Zaire, and earlier known as the Belgian Congo (1908-1960). Under that last name, it was the personal property of King Leopold II of Belgium and subject to vicious exploitation. In 1909, Doyle wrote a vigorous polemic (45,000 words in just eight days) that helped lead "to radical changes in the way the colony was governed." About half of *The Crime of the Congo* is included here. It may seem of only historical interest, but it casts considerable light on how colonialism lead to present conditions.■

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BRASS TACKS

Dear Dr. Schmidt,

In recent issues, your 1998 editorial, "The Fermi Plague," has been much discussed. The point of the editorial was that technological civilizations may reach a point where a small group of fanatics, under a determined leader, might gain access to enough deadly technology to bring down that civilization.

As you and several readers have pointed out, the events of 9/11/2001 and the threat of terrorists using nuclear and biological weapons makes it feel like we have reached that point.

I have a suggestion for *Analog* to do something about it. Okay, we have a science-fictional situation here, a threat to civilization as we know it. As you said in your June editorial, it's an "experiment that's best done—at least initially—in the science fictional laboratory." Why not put our best SF minds to work on it?

Analog could hold a contest, open to seasoned writers and newcomers alike, to write the best stories they can about this type of threat to civilization and, more importantly, ways to deal with it. Stories would not have to be about the current events; recast the situation to an orbital society, or a far-future, other-planet setting. The only criteria is that the solution be logical and realistic: no Deus ex Machina, no truce imposed by godlike aliens (not that *Analog* would run a story like *that* in the first place!). This would make for sufficiently diverse entries that you could conceivably run several of them in a single oversized "contest" issue.

I know that SF writers aren't prophets or world-savers. They're storytellers, and any prizes should be awarded for plain damn good *stories*, not blueprints for peace.

But, if in one or two of those stories, there was a germ of an idea that just might lead to something that *worked* . . . the prize might be something we could all profit from!

Kevin P. Breen

That's very much like what I had in mind when I reposted "The Fermi Plague," with a few added comments, on our website shortly after 9/11, but we don't need a special contest to do it. Every issue of Analog *is "a contest, open to seasoned writers and newcomers alike," and this is certainly one of many areas that those writers are exploring. If you haven't submitted and would like to, please see our submission guidelines on the website (www.analogsf.com) or send a business-sized SASE for a hard copy.*

Dear Dr. Schmidt:

Regretfully, Kevin Levites "Zero Tolerence" story, published in "Probability Zero" in the July/August issue, is in the wrong category. It probably should be under your "Science Fact" section, except that there's nothing scientific about it.

Once again, truth is stranger than fiction. A web site I stumbled across (http://www.thisistrue.com/zt.html) collects news reports about legal/social intolerance, including zero-tolerance cases, and quotes a news report about a

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child suspended from school in New Jersey for pointing his index finger and saying "bang, bang" during a recess game of cops and robbers.

Mike Mintzer

The author replies . . .

I was upset to hear about the unfortunate child, but I can't say that I didn't expect to hear about this or something like it.

It has always bothered me that it seems like it's human nature to respond to a problem by taking its opposite to a diseased extreme.

I know, for example, of a disturbed thirteen-year-old student who smuggled a gun into school and murdered one of his teachers in a fit of adolescent pique.

I was peripherally involved in the case as a paramedic. My sister was one of the victim's students, and while I can't say that I knew the man, I had met him on career days. He was, by all accounts, a kind and gentle person who was dedicated to his students and the art of teaching, and he deserved much better than he got.

People responded to the shooting by implementing zero-tolerance policies, and I am worried. I worry that we give our children a double standard by letting them watch violence on television and suspending them from school for playing cops and robbers. I worry that patently unhealthy decisions almost always seem more appropriate and reasonable in the aftermath of a tragedy. I worry that there are powerful people who know this, and will shamelessly exploit a tragedy to further their own political agendas.

I also worry that people (as a whole) seem to ignore a healthy middle ground as a response to problems, and insist on choosing another extreme with its own set of new problems.

Dear Mr. Kooistra,

I much enjoyed your "Alternate View" column in the July/August '02 issue of *Analog* concerning "Forgotten Classic Science Books Every Science Fiction Writer Should Have." In fact, invoking the Durante Principle ("Everybody Wants to Get in the Act"), I was inspired to suggest some books myself for possible discussion in future columns. I would surprised if you didn't have a few of these in mind already, however. . . .

1. *Profiles of the Future* by Arthur C. Clarke. Good discussion of what's possible and what probably isn't, with reference to science-fiction concepts. Most of it holds up, though these days the further fringes of physics are taking things like multiple dimensions, alternate universes, and time travel more seriously than the Clarke writing the book might have dreamed likely. I glommed onto this book as a kid and had some idea of using it as my primary source for writing SF that would amaze everyone with its prophetic accuracy. Unfortunately, that would have included making "ground effect machines" the land-based transportation of the future (i.e. wheelless vehicles riding on cushions of air), since Clarke touted them rather enthusiastically.

2. *Habitable Planets for Man* by Stephen H. Dole. When I was hanging around the Los Angeles SF club in the early '70s, this book was highly regarded by some of the working SF writers. Originally published in 1964, my copy is a 1970 second edition. As a general discussion of what makes a planet habitable (with the emphasis on extra-solar planets to be discovered, visited, and even colonized in the distant future), it seems pretty valid yet.

3. *Is There Life on Other Worlds?* by Poul Anderson. Anderson and I exchanged letters on a few occasions, and I once mentioned this book as *the* book on extraterrestrial life. He demurred, saying it was woefully out of date. I don't know . . . I recently read David Darling's *Life Everywhere* (2001), which covers much the same ground,

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and I can't think of anything that blatantly contradicts what Anderson wrote forty years earlier. True, an updated version of *Is There Life on Other Worlds?* would take into account four decades of continued research in the life sciences as well as other advances and controversies that have roiled the scientific waters since (like: is a proportionately enormous moon like Earth's necessary for the evolution of life?). But as an introduction to the basic issues and problems of extraterrestrial life, most of what Anderson wrote seems to still hold. (Probably because—the Mars rock aside—no undisputed sample of life from elsewhere has been discovered yet, so the subject is still as speculative as it was when Anderson wrote.) Also, Anderson wrote the book from a science-fiction writer's perspective and often referred to SF concepts, making it especially relevant for the would-be SF writer. And finally, Anderson could write real purdy. Even if the book was as hopelessly obsolete as Lowell's *Mars as the Abode for Life,* it would still be worth reading for the enjoyment of Anderson's prose.

Well, these are my suggestions. I hope you at least find them amusing if not useful. . . .

Dwight R. Decker

Dear Dr. Schmidt,

I agree with Dr. Howe's assertion that nuclear power has a role in space exploration, but I was puzzled by his article. First, he seems to lump the problem of boosting payload into earth orbit and the problem of reducing the time required for interplanetary travel together. Second, he implies that the only two viable propulsion alternatives are chemical and nuclear.

So far as interplanetary travel is concerned, there are clearly several other alternatives, most notably ion and plasma drive systems. The recently completed mission of the *Deep Space I* spacecraft was a successful test of the former. An ion drive system is also being used to boost a communications satellite into a twenty-four-hour orbit, following the premature shutoff of the upper stage. An example of plasma propulsion, the experimental VASIMR engine has been described in an article in *Scientific American* by NASA astronaut Franklin Chang-Diaz. It would appear that NASA is once again looking at the possibility of using nuclear power in space, in order to efficiently generate the electrical power needed by a large VASIMR unit.

Electric drives are capable of far higher exhaust velocities than either chemical or nuclear power: Thirty km/sec for ion drives and 300 km/sec for plasma, versus 9 km/sec for nuclear. For travel to the asteroids or planets, the electric systems are clearly superior for unmanned missions and may be superior for manned missions as well. Of course, these are propulsions systems born and bred for use in space. They require a good vacuum to operate, and they produce very small amounts of thrust.

Boosting a payload into orbit requires a propulsion system that works well in or out of the atmosphere and produces lots of thrust. I don't understand why Dr. Howe chooses to compare nuclear power to the Delta II and Titan boosters. They are old birds, not very competitive as commercial boosters. And NASA seems to be serious about a program to create a space transportation system with reusable but otherwise conventional boosters, which would orbit payloads for $1000 per pound.

I would like to hear about creating an atomic booster rocket, but that means creating one with very high thrust. Dr. Howe failed to discuss the problem of scaling up nuclear rockets to the size needed to orbit a 50,000 to 100,000 pound payload. Just how hard would that be? I would want to know just how much hydrogen would be expelled by such a rocket in order to evaluate the development problems

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and risks involved.

Having said all that, I welcome this article. This is a topic that needs to be discussed. This past week I saw a press conference held by the astronauts on the ISS, one of whom was Franklin Chang-Diaz. He clearly had been discussing new space technology with the other astronauts, because they referred to it in their answers. But for reasons I don't understand, Mr. Chang-Diaz himself kept his comments very general to the point of vagueness. I don't know why!

John T. Silver

The author replies. . .

Mr. Silver raises some excellent questions with regards to my article on advanced space propulsion. First of all, I should make it clear that the reason I chose to write about nuclear rockets is to show that, from a technical perspective, this one technology could allow both cheap access to space and rapid transits of humans to Mars. None of the other propulsion concepts mentioned by Mr. Silver can achieve this.

Mr. Silver also questions the performance of a nuclear rocket. If the thrust-to-weight ratio of the Phoebus-2 nuclear-engine tested in the late 1960s (thrust of 250,000 pounds with a specific impulse of 850 s) could be improved by only a factor of two, using today's materials, then four times the payload of a Delta II could be put into orbit at $500/lb-payload with a rocket that cost roughly the same as the Delta II—roughly 20,000 lb. The same engine could allow a crew of six humans to execute a one-year round-trip mission to Mars with a two-month stay on the surface—enough time to name every rock in a ten-kilometer radius.

Mr. Silver is certainly correct that electric propulsion systems offer a potential advantage for unmanned missions to the outer planets. The debate between the Nuclear Thermal Rocket (NTR) school and those supporting Nuclear Electric Propulsion (NEP) has raged for over a decade. Clearly, NEP is ideal for unmanned missions to planets or to deep space. I disagree, however, that NEP is suitable for human missions to nearby planets where short trip times are needed. Because the specific impulse of an NTR is close to the final speed required for the mission, much of the mass of the ship is propellant and specific impulse is a good figure-of-merit for the performance. For NEP-type missions, however, the specific impulse is so high that the mass of fuel is small compared to the platform—thus, the figure of merit is the specific mass, i.e., kilogram per kilowatt, not specific impulse. In the late 1980s, NASA and the Department of Energy set out to build a state-of-the-art reactor for space propulsion called the SP-100. The SP-100 would have had a specific mass of 35 kg/kw. The SP-100 would enable a ten-year mission to Pluto but could not have executed a manned mission to Mars. For human missions, an NEP system would require a nuclear reactor with an output of near one gigawatt of heat to run for the entire mission. The specific mass of the entire system would have to be below 5 kg/kw. This technology is far off.

The VASIMR concept mentioned in the letter is a good example of a high power electric thruster. However, of the three major components of the thruster—the helicon source, the RF booster, and the magnetic nozzle—only the helicon source has been operated. This has a specific impulse of around a thousand seconds and is relatively heavy compared to other electric thruster concepts such as the Hall thruster. In addition, no power source above 25 KW has been developed to operate in space, let alone tested. The VASIMR idea requires power levels above 100 KW to the best of my knowledge.

Aside from the power level, continuous operation of a high-power system in space or in a space-type environment

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has not been demonstrated and in my opinion is a high-risk option. The ability to apply high levels of thrust, a feature of the NTR, enables unforeseen circumstances to be countered where the low thrust offered by an electric system leaves a crew at the mercy of the mission profile calculations—something that Mars Explorer showed to be a fatal dependency. I am not against the use of electric thrusters by any means—they are ideal for certain missions. After twenty years of examining space propulsion concepts, though, I have concluded that a nuclear rocket may offer humanity the best chance of getting into space and of exploring the nearby planets. This is a tested technology. All we need is the will—and to not fear the fire.

Dear Stan Schmidt,

Your question of "what is the authentic state?" of an ecosystem, and the need to go forward rather than back ("Ecorestoration," July/August 2002) is important not only when considering natural ecosystems, but also in the perhaps more self-conscious world of evolving corporations and other institutions.

Scenario: a Board of Directors observes that inspired creativity has gone extinct among the employees of the thousand-person corporation under its stewardship. Profits are still coming in, but what about the future? Taking its job seriously, the Board demands that the CEO reintroduce the species of independent creator that made the company what it is.

Ever try to integrate inspirational, independent risk-takers into a bureaucracy and have them propagate naturally? Let's see how they react when bureaucrats with half their IQ try to diddle with their reproduction or expose them to toxic cultural waste. What happens when the reintroduced species starts marking large territories, just like the founders did years ago? Will the predators that always lurk in sizable organizations force these potential usurpers into perpetually defensive postures, negating the usefulness of their reintroduction and rendering them dangerous in unanticipated ways? Will the CEO or the Board embrace or even acknowledge responsibility for the outcome?

Perhaps the CEO could tell his VP of research to commission the building of little enclaves with subtle boundaries to preserve the free-thinkers: a kind of wildlife park. No matter what you do, you will not recover the original ecosystem, which never was stable in any case, and the results could be hazardous for everyone.

Steven Bittenson

Dear Mr. Schmidt,

As a long time reader of *Analog* (38 + years . . .), I must point out a frequent error that comes up in even the most respected authors' stories. In particular, I am referring to Jack McDevitt's "Oculus" where George had "jury rigged" a scanner. No, it is *jerry rigged*. I expect better of *Analog!* I have noticed this error many times lately, even from the likes of Larry Niven. It is the ultimate responsibility of the editor to make sure the author gets it right. Unfortunately, we are all becoming dependent on spell checkers to "think" for us! The July/August is a great issue—keep up the good work!

Bob Thornburg

Thanks for your note, but I'm afraid you're mistaken, and we did exercise our responsibility to check. According to at least three dictionaries (including Webster's Third New International), "jury-rigged" is exactly right, and "jerry-rigged" is not even listed as an alternative. There is another word, "jerry-built," which is probably etymologically related and has somewhat different meaning, and I suspect that's what you're thinking of. ■

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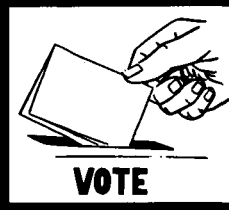

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We are more often frightened than hurt: Our troubles spring more often from fancy than reality.

—Seneca

Not being able to govern events, I govern myself, and apply myself to them, if they will not apply themselves to me.

—Michel de Montaigne

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UPCOMING EVENTS Anthony Lewis

17-19 January 2003
ARISIA '03 (Boston area speculative fiction conference) at Boston Park Plaza Hotel, Boston, MA. Guest of Honor—Harry Turtledove, Fan Guest of Honor—Anthony R. Lewis. Registration—$30 until 30 November 2002, $40 thereafter and at the door. Info—Building 600, PMB 322, 1 Kendall Square, Cambridge MA 02139. info@arisia.org; www.arisia.org.

24-26 January 2003
MARSCON (Southeastern Virgina gaming/relaxacon) at Clarion Hotel, Williamsburg VA. Info—MarsCon, c/o Michelle Fraser, Box 8143, Yorktown VA 23693; info@marscon.net; www.marscon.net.

24-26 January 2003
VERICON (Harvard SF/anime/gaming conference) at Sever Hall, Harvard Yard, Harvard University, Cambridge MA. Guests—Patricia C. Wrede, T. Campbell, Mike Kunkel, Judd Winick, Catherine Asaro, Jeff Paris, Adam Golaski, Tee Morris, Charles Vess. Info—www.vericon.org

28 August-1 September 2003
TORCON 3 (61st World Science Fiction Convention) at Metro Toronto Convention Centre, Royal York Hotel (and others), Toronto, Ontario, Canada. Guests of Honor—George R.R. Martin, Frank Kelly Freas, Mike Glyer. GoHst of Honor—Robert Bloch. TM—Spider Robinson. Registration—Attending CAD220/USD145, Supporting CAD60/USD40, Child CAD60/USD40. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Info—Torcon 3, Box 3, Station A, Toronto, Ontario M5W 1A2, Canada; email—info@torcon3.on.ca; URL—www.torcon3.on.ca (Note to US readers—first class postage to Canada is $0.60 for the first ounce.)

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